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Automatic Bead Stringing Machine

Huy Dinh
anhuydinh90@gmail.com

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Automatic Bead Stringing Machine

*By
Huy Dinh*

*Central Washington University
Mechanical Engineering Technology*

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1. INTRODUCTION

Motivation:

The art of stringing beads together has been known since ancient times. Human learn how to pierce objects through drilling holes as an advanced beading process. There would be a great demand for beads and they appear more and more in human daily life. Many things made from bead string such as jewelry, furniture, house decoration. The beading process will do manually by hands of workers. This process takes a lot of effort and cost for labor. The automatic bead string machine will helps to free the work effort and low the labor cost.

Function Statement:

A device is needed that will accept a bin of beads and position/place them into a string

Requirements:

Bead string machine will string beads quickly and efficiently to eliminate hand and eye fatigue. Special designed for round bead, suitable for 6-12 mm round bead. This is a great machine for jewelry making, saving time and labor cost. The following are design requirement that the bead string machine should meet:

- Weight less than 20 pounds
- Easy to operate and use. Has 5 steps to install.
- Production rate 150 beads string per minutes
- Cost less to manufacture

Engineering Merit:

This project has many engineering criteria. The movement of the device will involve dynamic movements as well as kinematics. There will need to be safety factors built into the device.

The scope of this effort:

The bead strings machine's has 3 main parts: the funnel, the roller system and the gear system. Motor will connect to the roller and the gear system. The funnel is where to put beads. Beads will go to roller system and connect to the last part is gear system. The material is made of stainless steel because of its high strength, high stiffness, good machinability, good formability and goof corrosion resistance.

Benchmark:

Comparison between the bead string machine with the others design on the market. The unit is designed in a way that easy to use, comfortable and affordable. The price tag will cheaper than other machine with same functions.

Success of the project:

The automatic bead string machine will increases the productivity, the quality and quantity. With high production rate and reduce the labor cost and saving time.

2. DESIGN AND ANALYSES

Approach:

Design and manufacture a simple system to facilitate adjusting needs of the bead string machine. There is currently nothing on the market that is adjustable and scalable to the users' needs. A new design is needed that could be adapted to an individual's current needs.

Design Description:

The bead strings machine's has 3 main parts: the frame, the roller system and the gear system. Motor will connect to the roller and the gear system. The funnel is where to put beads. Beads will go to roller system and connect to the last part is gear system. The material is made of stainless steel because of its high strength, high stiffness, good machinability, good formability and goof corrosion resistance.

Benchmark:

A benchmark for this project is very hard to come up with because as research shows this is no such thing as bead string machine combination available on the market today. The closest thing available is a machine comes with rollers and do it manually. This is not even close to offering the same level of accessibility as this device. With that device, people have to put the string on bead manually. The device mentioned available on the internet is advertised at \$199, so it is slightly cheaper, but it offers much less accessibility.

Performance Predictions:

The device is predicted to meet and exceed every design requirement. It will be built with strict enough tolerances and of the highest quality aluminum alloy to ensure the device will exceed all requirements.

Description of Analyses

As showing in Appendix A. First, figure A-1 show a simple calculate for the frame of the project. The requirement thickness of material is 0.077 inch. Second, figure A-2 show the maximum shear force and maximum bending moment is 960 lb.in. Thirds, figure A-3 show how much material have to use for the machine which is at 330 in² for the frame cover. Figure A-4 is induction motor calculation. Given power at 15W, current equal 0.14A and voltage at 110V. calculate the torque at 0.11N.m and resistance equal 785.7 Ω . On figure A-5, machine will use main motor with 50W, $V = 220V$ and speed at 1200rpm. The torque (N.m) from this machine equal 0.4N.m and resistance is 1.4k Ω .

This machine will use 6 spur gears total. The next analysis figure A-6 will calculate spur gear 1. Given number of teeth is 30, pitch diameter is 2.5 and diametral pitch is 12. Use these values to calculate the circular pitch (P) equal 0.2618. Outside diameter (D_o) equal 2.6 inch, root diameter (D_R) equal 2.2917 inch and the center distance equal 4.67

The next analysis figure A-7 will calculate spur gear 2. Given number of teeth is 34, pitch diameter is 2.5 and diametral pitch is 13.6. Use these values to calculate the circular pitch (P) equal 0.2310. Outside diameter (D_o) equal 2.6471 inch, root diameter D_R equal 2.3162 inch and the center distance equal 4.118.

The next analysis figure A-8 will calculate spur gear 3. There are 4 spur gears of this type. Given number of teeth is 32, pitch diameter is 2.5 and diametral pitch is 12.8. Use these values to calculate the circular pitch (P) equal 0.2454. Outside diameter (D_o) equal 2.6563 inch, root diameter D_R equal 2.3047 inch and the center distance equal 4.375

On figure A-9 calculates the chain length to connect gear 1 and gear 2. Total chain length is 15.5 inch. Gear ratio equals 1.133:1 and the sprocket center is 3.75 inch . The chain speed at 1200 rpm on small sprocket. Every 15 chain rotations the same tooth on small sprocket contact the same chain link equal 48% optimal. Every 17 chain rotations the same tooth on large sprocket contact the same chain link equal 48% optimal.

Figure A-10 calculates torque of main motor. The given power is DC 12V, current = 1.8 A, Watt= 36W and speed at 400 rpm. Torques of this motor is 0.86 N.m.

Figure A-11 calculates pitch diameter of driving and driven. Result for pitch diameter of 30 teeth is 2.39 in and 34 teeth is 2.7in. The last figure A-12 calculates theoretical center distance of the

chain length and 2 spur gear. Chain length is 394 mm and 2 gear have 30 teeth and 34 teeth. The result for actual theoretical center distance is 45.25mm

Scope of Testing and Evaluation

The scope of testing and evaluation on the bead string machine must finish 150 beads string in 1 minute.

Analyses

Design Issue:

- Gear system to holding bead string
- Roller system to put bead on string

Calculated Parameters

As showing in Appendix A. First, figure A-1 show a simple calculate for the frame of the project. The requirement thickness of material is 0.077 inch. Second, figure A-2 show the maximum shear force and maximum bending moment is 960 lb.in. Thirds, figure A-3 show how much material have to use for the machine which is at 330 in² for the frame cover. Figure A-4 is induction motor calculation. Given power at 15W, current equal 0.14A and voltage at 110V. calculate the torque at 0.11N.m and resistance equal 785.7 Ω . On figure A-5, machine will use main motor with 50W, $V = 220V$ and speed at 1200rpm. The torque (N.m) from this machine equal 0.4N.m and resistance is 1.4k Ω .

This machine will use 6 spur gears total. The next analysis figure A-6 will calculate spur gear 1. Given number of teeth is 30, pitch diameter is 2.5 and diametral pitch is 12. Use these values to calculate the circular pitch (P) equal 0.2618. Outside diameter (D_o) equal 2.6 inch, root diameter (D_R) equal 2.2917 inch and the center distance equal 4.67

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Device: Parts, Shapes and Conformation

The Bead String Machine was manufactured following parts:

1	Main Motor
2	Silicone Rubber Roller
3	Funnel
4	Rubber band
5	Spur gear 1
6	Spur gear 2
7	Spur gear 3
8	Cooling Fan (Square 12mm x12mm)
9	Plastic elevator circle
10	Nuts, Bolts and Washers
11	Square Tube 6063-T52-Extruded (84")
12	Spray paint

Device Assembly, Attachments

This device consists of the parts listed in Parts, Shapes, and Conformation above. All parts were secured to each other with the latches recorded inside the appendix.

Tolerances, Kinematics, Ergonomics, etc.

The tolerances will have to be fairly tight. The tolerances can't be completely decided until the device is actually assembled. The tolerances are expected to be within .030" to ensure proper fit or within .005" to make the device look more appealing.

Technical Risk Analysis, Failure Mode Analyses, Safety Factors, Operation Limits

There are many sorts of possible risks. For example, there is a budgetary danger of going over spending plan. The budget for this project was \$330. There was also additionally of a scheduling risk. The Bead String Machine was required to take close to 40 hours to manufacture.

3. METHODS AND CONSTRUCTION

Methods

This project was designed and analyzed using resources and personnel at Central Washington University Mechanical Engineering Technology department. The project parts were also manufactured and fabricated at the Mechanical Engineering Technology department and workshops. Appendix B shows all the parts was manufactured and fabricated.

Construction

The construction of this project will take place during winter quarter at Central Washington University and workshops. The roller system will be made within the machine shop using either CNC machines or manual mills and lathe machine. It is expected to take about 2-3 weeks to complete all of the manufacturing required to begin assembly. The gears system, cooling fan, motor will purchase online through Amazon, McMaster and Ebay.

Bead string machine will be built in 3 different sections, the truss system, the roller system and the gear system. The truss and roller system of the this machine will be manufactured.

Assembled parts include spur gears, cooling fan, funnel, plastic elevator system.

Description

Main Motor has 2 parts. Part 1 will connect to the roller system by using rubber band. Part 2 will connect to the gear system. The motor use 220V power and speed at 1200rpm. Torques of this motor is 0.86 N.m. The back of motor connect to the frame. Colling fan (size 80cm x 80cm) helps to reduce heat from the main motor.

Top of a machine is funnel connects to the roller system. The roller system has 3 main parts. Top cover, sides, and two rollers. Top cover using aluminum material with dimension 1.4 inch width

and 6 inch length. Top cover keeps beads fall out of the roller. The funnel will connect to the top cover of the machine. Sides part's dimensions are 1.14 inch width and 2.36" length. Sides parts function to hold the roller system. Connect the rollers with ball bearing.

Gears system has 6 gears. 5 gears with 32 teeth and 1 gear with 28 teeth. Gears will connect with plastic elevator to delivery bead from the roller system. Pair gear 28 teeth and 32 teeth will connect through KCM 25H chain with 62 links. This pair of gear will connect to the motor to run the gears system.

Beads go into the funnel to the roller. A top cover of roller system prevents bead fall out of rollers. Since beads place on the roller, the roller will run and make beads roll, therefore, the center of beads will go straight to the needle. Beads will drop to the gear system through 24 inch needle. This needle will go around the gear system in order to deliver the beads to the final destination. The base will be welded and back support will mount to base with an angle of 5 degrees. With this angle, the beads and fall to gear system through the needle by the gravity.

[Manufacturing issues](#)

The most complicated issue of this machine during the construction is the connection of the gear system and the roller system.

The roller system includes a top cover, both sides, and two rollers. These parts have to manufacture by CNC machine, milling machine, and lather machine. It takes more time to make these parts and gets the most accurate dimensions to assemble to the machine.

The motor using 220V power, therefore, It will need an AC adaptor to convert the power to 220V from 110v.

During manufacturing, the design needed to be modified due to the raw material being larger than the initial design. The elevator that attaches to the gear system had to be ordered online instead of manufactured. The initial design of the elevator was going to be 3D printed using ABS or PLA material. However, quality the material did not meet the standard and quality, therefore, this part was ordered online instead. The new material for elevator is plastic. The rollers will be made on the CNC machine instead of the lathe as originally designed. They will have 2 pieces of roller.

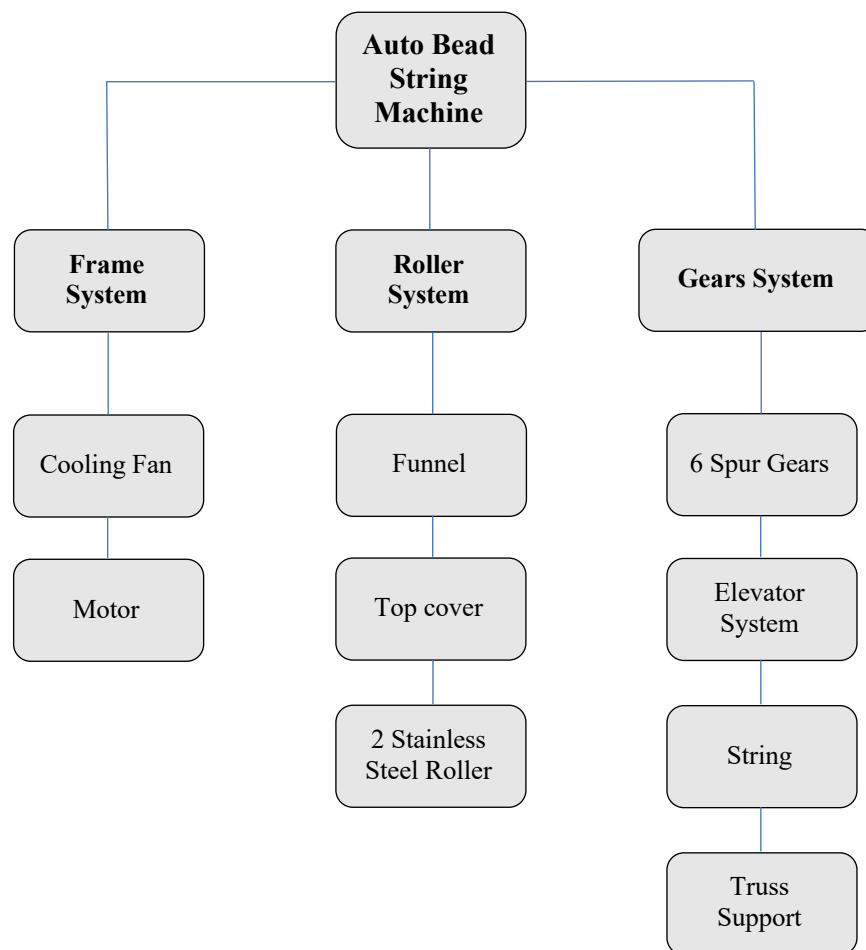
In manufacturing the roller system has been several issues. At first, it took a long time to manufacture as planned. This part has been manufacture three times. Secondary, The first roller manufactured did not fix the system. Therefore, it required to redesign and modify again. The

new design has increased the length by 0.5” to fit in the side parts and to attached the pulley. The extension part connected with a larger pulley (draw B14). The small one, which is coupled to the main motor(draw B15) attached to the larger one via a rubber belt.

Another issue encountered during this project was the frame. The original frame was designed to be a 6.1” x 11.5” square tube. This would have been much less useful to place gear system and roller system. Having extra space on each side could have easily arrange parts. The new design had an increase of 0.5” on both sides.

Drawing Tree and Drawing ID's

The following drawing tree illustrates the order that the bead string machine was designed in Solidworks.



Parts list and labels

The following excel spreadsheet is the most current list and cost analysis.

PARTS LIST AND BUDGET						
SENIOR PROJECT TITLE		Bead String Machine				
		Cost:				
ITEM ID	ITEM Description	Item Source	Price/Cost (US Dollars) (\$ / hour)	Quantity (or hrs)	Subtotal	Actual \$
1	Main Motor	Ebay	40	1	40	
2	Silicone Rubber Roller	Ebay	21	2	42	
3	Funnel	Ebay	10	1	10	
4	Rubber band	Home Depot	10	1	10	
5	Spur gear 1	Mcmaster	22.85	1	22.85	
6	Spur gear 2	MCmaster	25	1	25	
7	Spur gear 3	MCmaster	25	4	100	
8	Cooling Fan (Square 12mm x12mm)	Ebay	15	1	15	
9	Plastic elevator circle	Ebay	5	5	25	
10	Nuts, Bolts and Washers	Home Depot	40	0.5	20	
11	Square Tube 6063-T52-Extruded (84")	onlinemetals.com	7.35	2	14.7	
12	Spray paint	Home Depot	5	2	10	
				Tot Est.\$	334.55	0 Tot Act. \$

4. TESTING METHOD

Introduction

The testing of this project will take place during Spring 2020 quarter at Central Washington University. The purpose of testing method for this project was to free the work effort and low the labor cost. The finish device must be:

- Weight no more than 20 pounds
- Easy to operate and use. Has 5 steps to install.
- Production rate 150 bead string per minutes. The diameter of beads at 8mm
- Cost no more than \$400 manufacture

Method/Approach

- Using timer to count the beads go on string per minute and 5 minutes
- Run machine in 1 minute and calculate the production rate

The primary testing will be based on device requirements. After testing, the measurement data, that will determine whether modifications may be taken into consideration to improve the device.

The first test is to weigh the machine, this test can be done on a weight scale. The second test is the installation of the machine. The machine can completely assemble under 5 steps. 5 parts are roller system, gears system, motor, switch, and cooling fan. The third test is testing the production rate. The purpose of this test is to check how many beads will go through this machine in 1 minute. The estimated production rate is 150 bead per minute. This test can improve by calculating beads for 5 minutes, 10 minutes, 15 minutes and 20 minutes. To compare the production rate during the given time.

Result

Base on the requirements and test plan, the machine meets all requirements. In the first test, the total weight of the machine is 16 lbs. This test is done by using a weight scale. In the second test, the machine assembled in 5 basic steps and took 15mins to install the process. Third test, the production rate purpose to check how many beads will go through the machine in 1 minute. This test will be tested by hand (traditional way) and by the machine. 3 trials of 1 minute of bead threading both by hand and by machine show the machine dominating. The average result was 17 beads per 1 minute after 3 trials by using hand. However, the result was higher when used machine with the average after 3 trials at 372 beads. The percentage change between the two methods is 2195%.

During the test process, there were some issues occurred. Time to assemble the machine took longer than planned due to: the gear system needed to set up perfectly to run, electric wires needed to attach to the machine's frame. During the production test, when put too many beads in the funnel. Beads always stuck in the funnel. They could not run to the roller system. This is a major effect on the result of the testing. The connection point between the roller and funnel needs to be fixed in order to get a better result for the next tests.

5.BUDGET & COST

One of the requirements was a sensible materials cost of under \$400 Appendix C contains a parts list in Figure C & D with associate costs from possible suppliers. The budget includes parts, transportation and labor the parts list includes an estimated and actual cost of each item was 12 purchased, the place of purchase, and a description of each item. The actual cost of the project was \$350 which is much chapter than was estimated \$400.

The proposed budget for this project is shown in Appendix D. The budget references the parts cost for this project shown in Appendix C

Changes in the proposed budget were made in the manufacturing process. The largest change was due to the parts list being revised. However, this did not affect the original budget. Another aspect that impacted the budget was the shipping and tax costs. These costs were estimated incorrectly before they were actually ordered, but it did not increase the total budget by too much more than originally planned.

The only change made to the budget during manufacture was the added labor hours. The amount of time spent on correcting manufacturing issues was not anticipated in the proposed schedule. When issues came up in testing, modifications had to be made to reconstruct or add new parts and then test the requirement again.

At this point, the budget for the bead machine project is \$350. This is under the proposed budget which is \$400. There were some changes in the budget plan such as materials, shipping, and tax costs. However, this did not over the planned budget. The initial design of the elevator was going to be 3D printed using ABS or PLA material. However, the quality of the material did not meet the standard and quality, therefore, this part was ordered online instead. The cost of this part is less than the planned budget. Before the cost for spring, there is nothing extra charge for the machine in this quarter.

PARTS LIST AND BUDGET						
SENIOR	PROJECT TITLE	Bead String Machine				
ITEM ID	ITEM Description	Item Source	Price/Cost (US Dollars) (\$ / hour)	Quantity (or hrs)	Cost: Subtotal	Actual \$
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3	Funnel	Ebay	10	1	10	
4	Rubber band	Home Depot	10	1	10	
5	Spur gear 1	Mcmaster	22.85	1	22.85	
6	Spur gear 2	MCmaster	25	1	25	
7	Spur gear 3	MCmaster	25	4	100	
8	Cooling Fan (Square 12mm x12mm)	Ebay	15	1	15	
9	Plastic elevator circle	Ebay	5	5	25	
10	Nuts, Bolts and Washers	Home Depot	40	0.5	20	
11	Square Tube 6063-T52-Extruded (84")	onlinemetals.com	7.35	2	14.7	
12	Spray paint	Home Depot	5	2	10	
				Tot Est.\$	334.55	0 Tot Act. \$

6. SCHEDULE

The schedule for the project will take place over three quarters. The first quarter (fall) will be when the proposal is written. The second quarter (winter) will consist of final design changes and construction of the design. Lastly, the third quarter (spring) will be when testing of the project

will be completed and when presentations will begin. The schedule was portrayed in an Appendix E. The schedule is further divided into plans per quarter. Some of the crucial activities in the project are developing and writing the proposal, dimensional and material analysis, sub-assembling, assembling, draws and testing of the device. The schedule depends on the intensity of the work, time, and availability of materials. schedule.

During the winter quarter, redesigns also had an impact on the project schedule. The original proposed design and analysis were expected to work exactly as planned, but with multiple parts added and others edited along with slight modifications in the overall design, the project got off schedule. The change of material for the elevator system took longer than the planned schedule. Moreover, the rollers required more time to manufacture also affected the project schedule. Changes had to be made to the Gantt Chart during construction, but that got the project back on schedule and allowed the device to be assembled and working by the deadline.

During manufacturing, The elevator that attaches to the gear system had to be ordered online instead of manufactured. The initial design of the elevator was going to be 3D printed using ABS or PLA material. However, the quality of the material did not meet the standard and quality, therefore, this part was ordered online instead. The new material for the elevator is plastic. Another issue is that the beads always stuck in the funnel, this also affected the result of the production test. To solve this problem, the funnel needs to expand on the size. Overall, the project finishes on time and under budget. All test meets requirements.

7. DISCUSSION

Project Risk analysis

The biggest risk factor that taken into consideration was time. The project was characterized by many redesigns and analysis, revising of the proposal, and material selection. This lead to the wastage of valuable time. It also leads to the cancellation of the analysis of some parts. The assembling and building phase also poses some risks. Many parts need to be machined and fabricated for the short remaining time. Lastly, lack of expert skills in production processes such as welding and operate machines are potential risk factors.

Successful

The success of this project to this far is attributed to the vast engineering knowledge in project management and planning, material science, mechanical design using Autodesk

AutoCAD and SolidWorks engineering software, Gantt charts, and production. However, the project has been challenging. This is because the project was an original work that is developed from the challenges faced. Some of the challenges experienced include overdesigning, material selection and analysis, and fabrication methods. That gave the ability to work on a tight schedule to ensure that the project was completed on time. With only a few weeks remaining, the project management process was continuing well as per the schedule.

Project Documentation

All project documentation can be found in the Appendix of this proposal; the documentation includes drawings, analyses, schedule, parts/budget lists, safety hazard forms, etc. If reference material is needed, please refer to the Appendix of this engineering report.

Next phase

The next phase of this project is the construction of this machine. The build process will begin in the beginning of winter quarter. The process will begin with manufactures parts for the project and order parts that also required for the project. Once all the parts/materials are finished, the process of assemble will begin. During spring 2020 will be tested process. All requirements need to be meet.

Manufacturing issues

Do dates, this project has seen several redesigns on parts. Many issues were only discovered during the manufacturing process. The first issue encountered was the side parts of the roll system. Completed parts are different from the original design. New side parts design has to machine hole for a bearing to support rollers. The purpose of this is to improve the movement of rollers on system.

Another issue encountered during this project was the frame. The original frame was designed to be 6.1" x 11.5" square tube. This would have been much less useful to place gear system and roller system. Having extra space on each side could have easily arrange parts. The new design had an increase of 0.5" on both sides.

During manufacturing, the design needed to be modified due to the raw material being larger than the initial design. The elevator that attaches to the gear system had to be ordered online instead of manufactured. The initial design of the elevator was going to be 3D printed using ABS or PLA material. However, the quality of the material did not meet the standard and quality, therefore, this part was ordered online instead. The new material for the elevator is plastic. The rollers will be made on the lathe machine instead of the CNC as originally designed. They will have 2 pieces of roller. The roller also redesigns to fit with the system by increased length by 0.5”.

Base on the requirements and test plan, the machine meets all requirements. In the first test, the total weight of the machine is 16 lbs. In the second test, the machine assembled in 5 basic steps and took 15mins to install the process. Third test, the production rate purpose to check how many beads will go through the machine in 1 minute. This test will be tested by hand (traditional way) and by the machine. 3 trials of 1 minute of bead threading both by hand and by machine show the machine dominating. The percentage change between the two methods is 2195%.

After the test process, the machine needs some modification with the gears to reduce the time set up. During the production test, beads always stuck in the funnel when place too many beads in a funnel. The funnel needs to be fixed by expanding the size.

8. CONCLUSION

This project is expected to be completed on time, accounting for possible setbacks and redesigns. The timeline has been created with the above average number of federal holidays during the period in mind. The budget is far under that of the competition while still allowing for some error. The assistance needed to complete the project has been confirmed to be available during the entire build period. All parts needed are currently in stock from multiple suppliers. The space required to build the project has been confirmed available and the construction team has the means to unlock the area.

Everything necessary to complete this project has been check. Extra time, space, and money has been built into the plans for this project. This project is a solid endeavor and should be approved immediately.

9. ACKNOWLEDGEMENTS

A huge thanks to Professor Charles Pringle, Dr. Craig Johnson, Professor John Choi and Mechanical Engineering Technology department at Central Washington University. The

resources at Central Washington University was really helping, provided the use of the Machine Shop, Materials Lab, Welding and logistics to achieve the final device. Auto bead string machine project would not be constructed without those resources.

10. REFERENCES

-“Machine Elements in Mechanical Design” Sixth Edition, Robert L. Mott

-www.mcmaster.com

APPENDIX A – ANALYSES

Figure A.1 Roller frame design

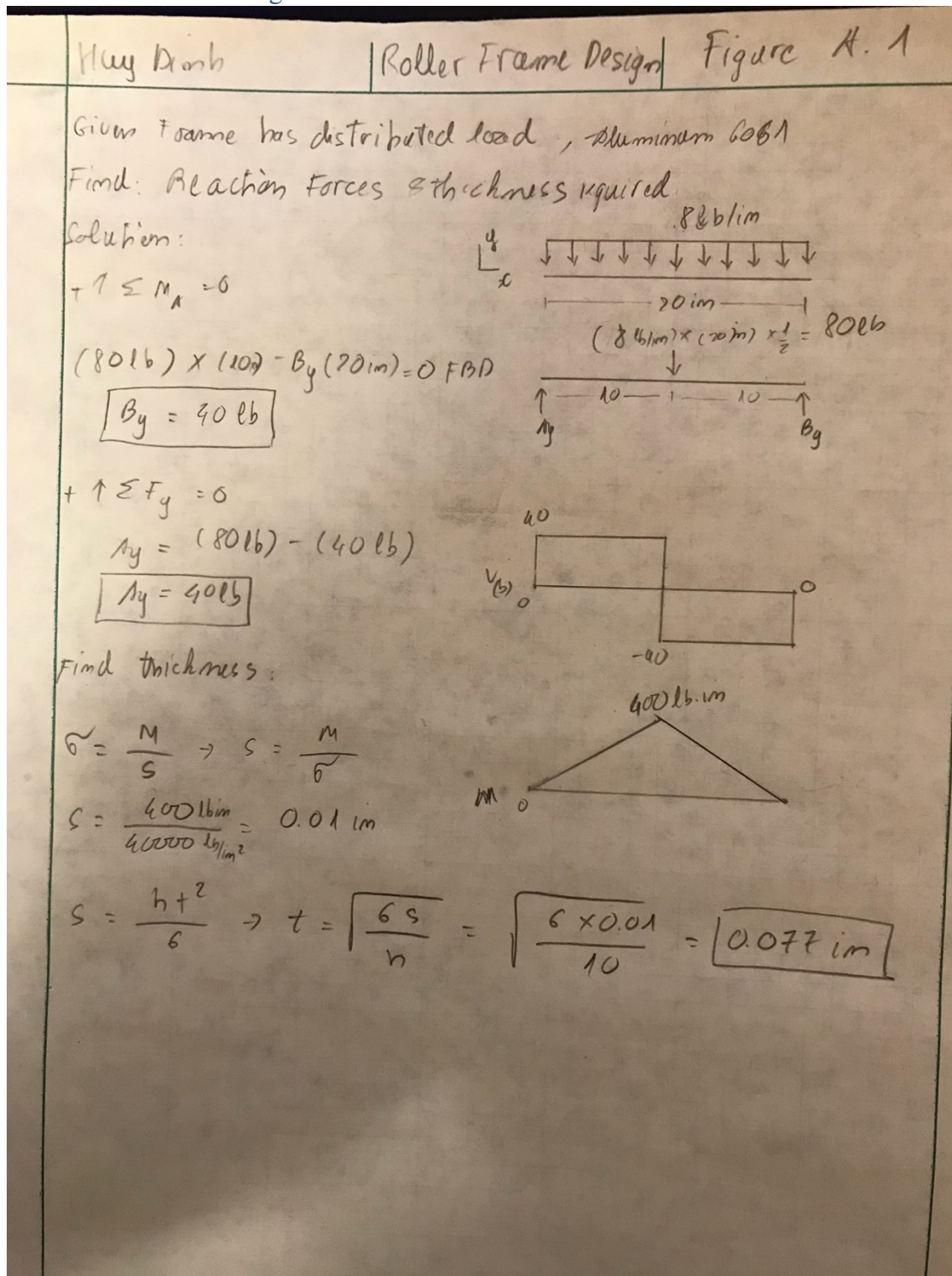


Figure A.2 Funnel support system

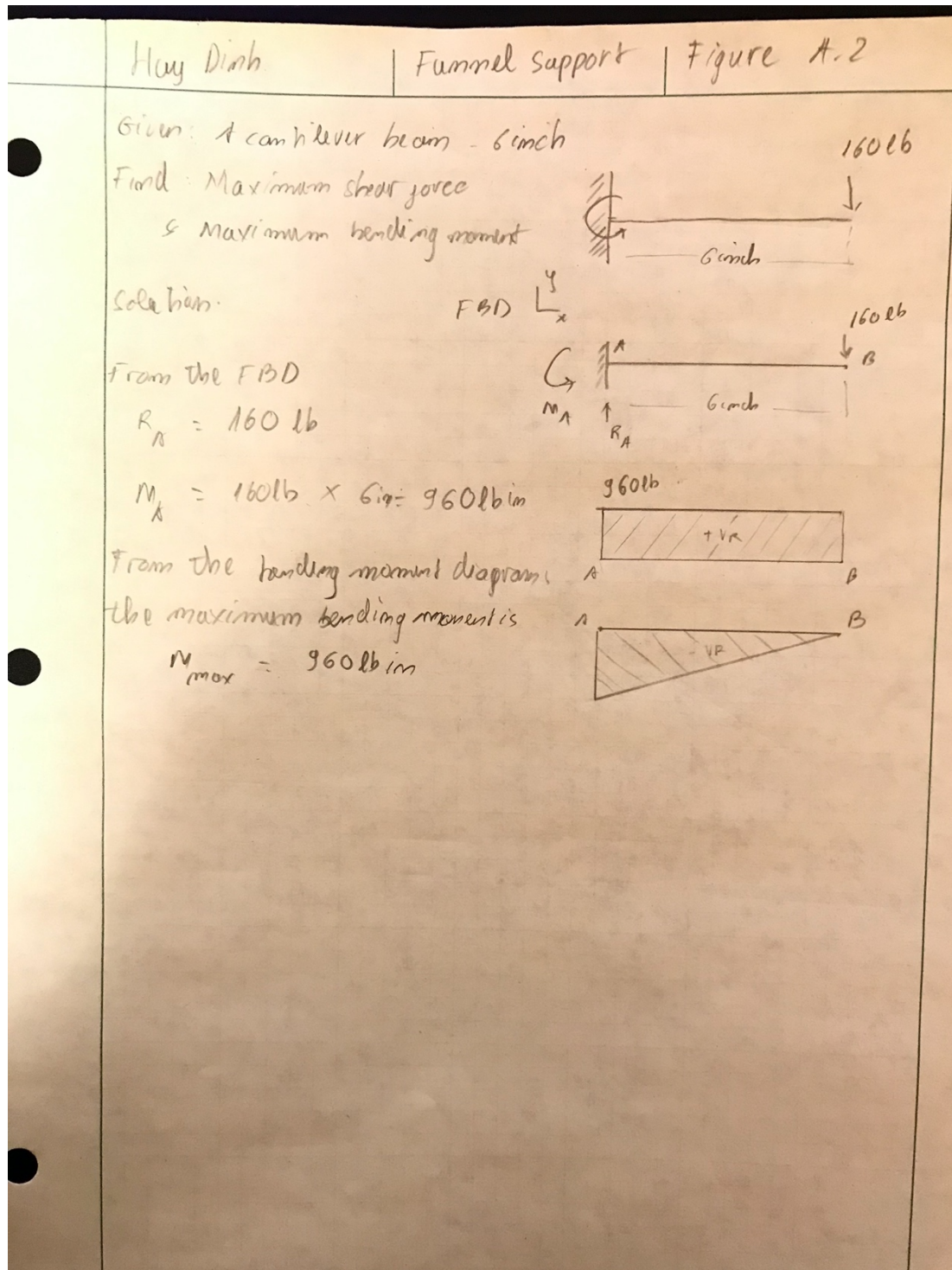


Figure A.3 Roller cover frame

Huy Dinh	Roller Cover	Figure A.3
<p>Given: Roller cover material (4 piece)</p> <p>Find: total area for roller cover.</p> <p>top & bottom dimensions.</p> <p>thickness : $t = 0.077 \text{ in}$.</p> <p>Length : 15 in</p> <p>width : 6 in.</p> <p>2 sides : length : 15 in.</p> <p>width : 5 in.</p> <p>Solution.</p> <p>Total area for top & bottom.</p> $A_1 = 15 \times 6 \times 2 = 180 \text{ in}^2$ <p>Total area for 2 side.</p> $A_2 = 15 \times 5 \times 2 = 150 \text{ in}^2$ <p>total area for roller cover frame:</p> $A = 150 \text{ in}^2 + 180 \text{ in}^2 = \boxed{330 \text{ in}^2}$		

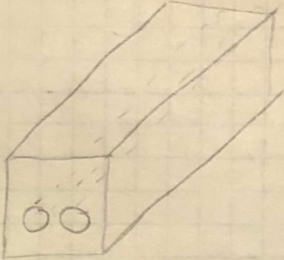


Figure A.4 Induction motor torque & resistance

Hom Dimh	Induction Motor	Figure A. 4
<p>Given: Machine has 3 induction motor.</p> <p>Find: Torque from the motor's power, Resistance</p> <p>Solution:</p> <p>Power: $15 \text{ W} = 15 \times 10^{-3} \text{ W}$</p> <p>$I = 0.14 \text{ A}$, $V = 110 \text{ V}$</p> <p>Speed: 1350 rpm</p> <p>Torque (N.m) = $9.5488 \times \text{Power (W)} / \text{Speed (RPM)}$</p> <p>$= 9.5488 \times 0.015 \text{ W} / 1350 \text{ rpm}$</p> <p>$= 0.11 \text{ N.m} = \boxed{0.94 \text{ lb.in}}$</p> <p>$V_{(V)} = I_{(A)} \times R_{(\Omega)}$</p> <p>$\Rightarrow R = \frac{V}{I} = \frac{110 \text{ V}}{0.14 \text{ A}} = \boxed{785.7 \Omega}$</p>		

Figure A.5 Main Motor

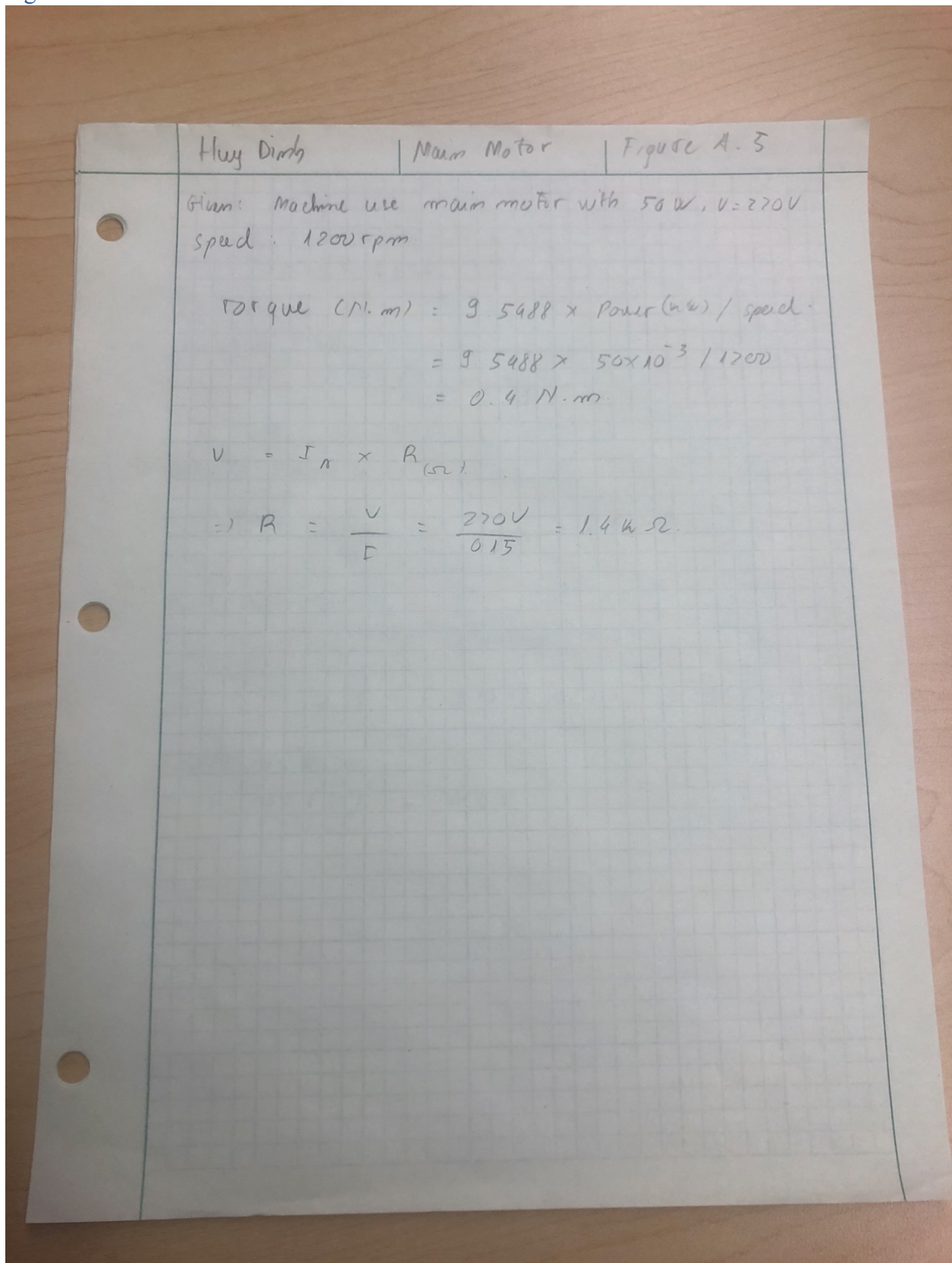


Figure A.6 Spur Gear 1

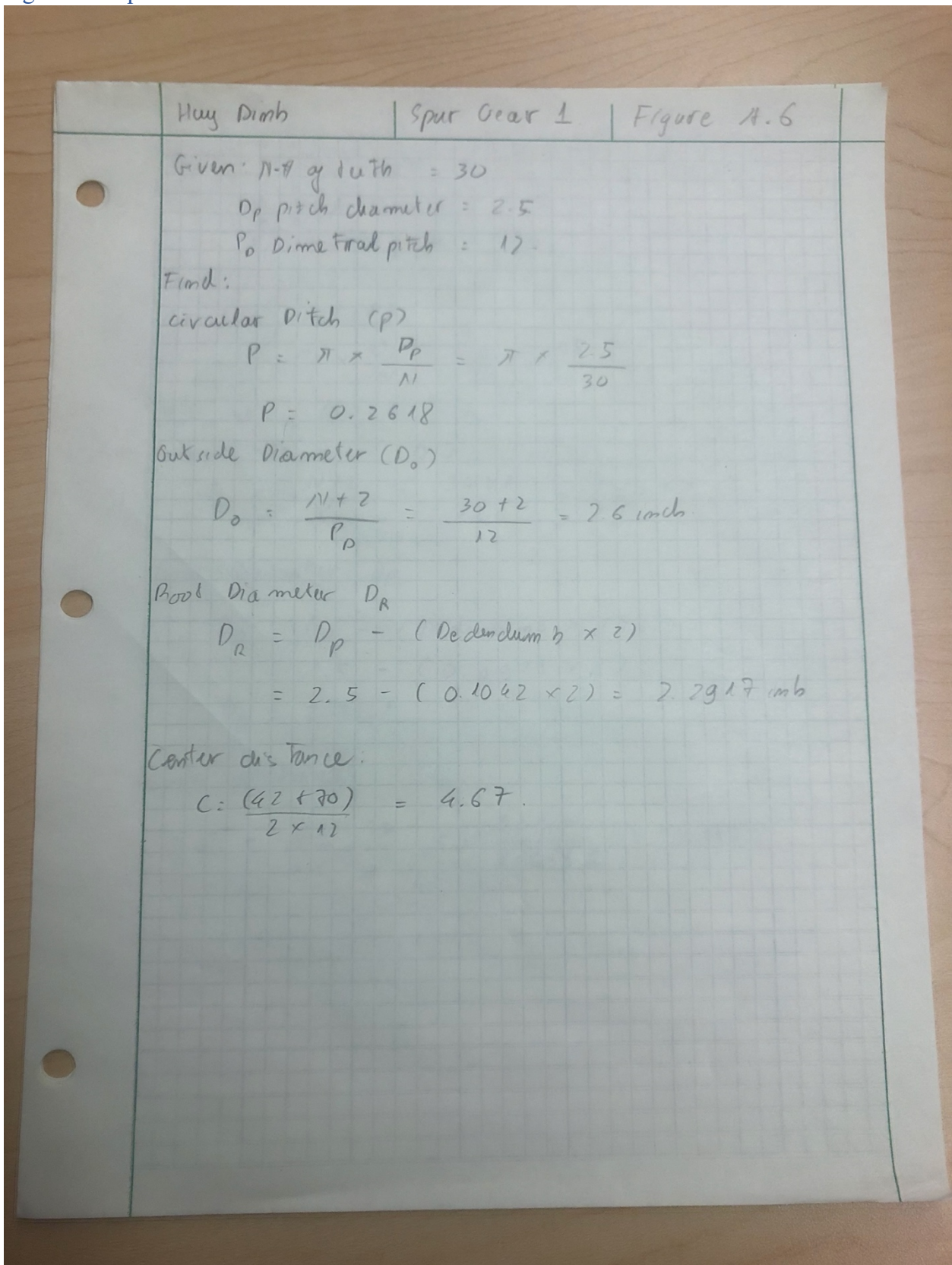


Figure A.7 Spur Gear 2

How Dinah	Spur Gear 2	Figure A.7
<p>Given: # of teeth $N = 34$ D_p pitch diameter = 2.5 P_D Diametral pitch = 13.6</p>		
<p>Find:</p>		
<p>Circular pitch (P)</p>		
$P = \pi \times \frac{D_p}{N} = \pi \times \frac{2.5}{34}$		
$P = 0.2310$		
<p>Outside Diameter (D_o)</p>		
$D_o = \frac{N+2}{P_D} = \frac{34+2}{13.6} = 2.6471$		
<p>Root Diameter D_R</p>		
$D_R = D_p - (\text{Dedendum} \times 2)$		
$= 2.5 - (0.0919 \times 2)$		
$D_R = 2.3162$		
<p>Center distance:</p>		
$C = \frac{42+70}{2 \times P_D} = \frac{42+70}{2 \times 13.6} = 4.118$		

Figure A.8 Spur Gear 3

Key Dimb	Spur gear 3	Figure A-8
<p>Given : # of teeth $N = 32$ D_p pitch Diameter = 2.5 P_D Diametral pitch = 12.8</p> <p>Find :</p> <p>Circular pitch (P)</p> $P = \pi \times \frac{D_p}{N} = \pi \times \frac{2.5}{32}$ $P = 0.2454$ <p>Outside Diameter (D_o)</p> $D_o = \frac{N + 2}{P_D} = \frac{32 + 2}{12.8} = 2.6563$ <p>Root Diameter D_R</p> $D_R = D_p - (Addendum \times 2)$ $= 2.5 - (0.0977 \times 2)$ $= 2.3047$ <p>Center Distance</p> $C = \frac{42 + 70}{2 \times P_D} = \frac{42 + 70}{2 \times 12.8} = 4.375$		

Figure A.9 Chain Speed

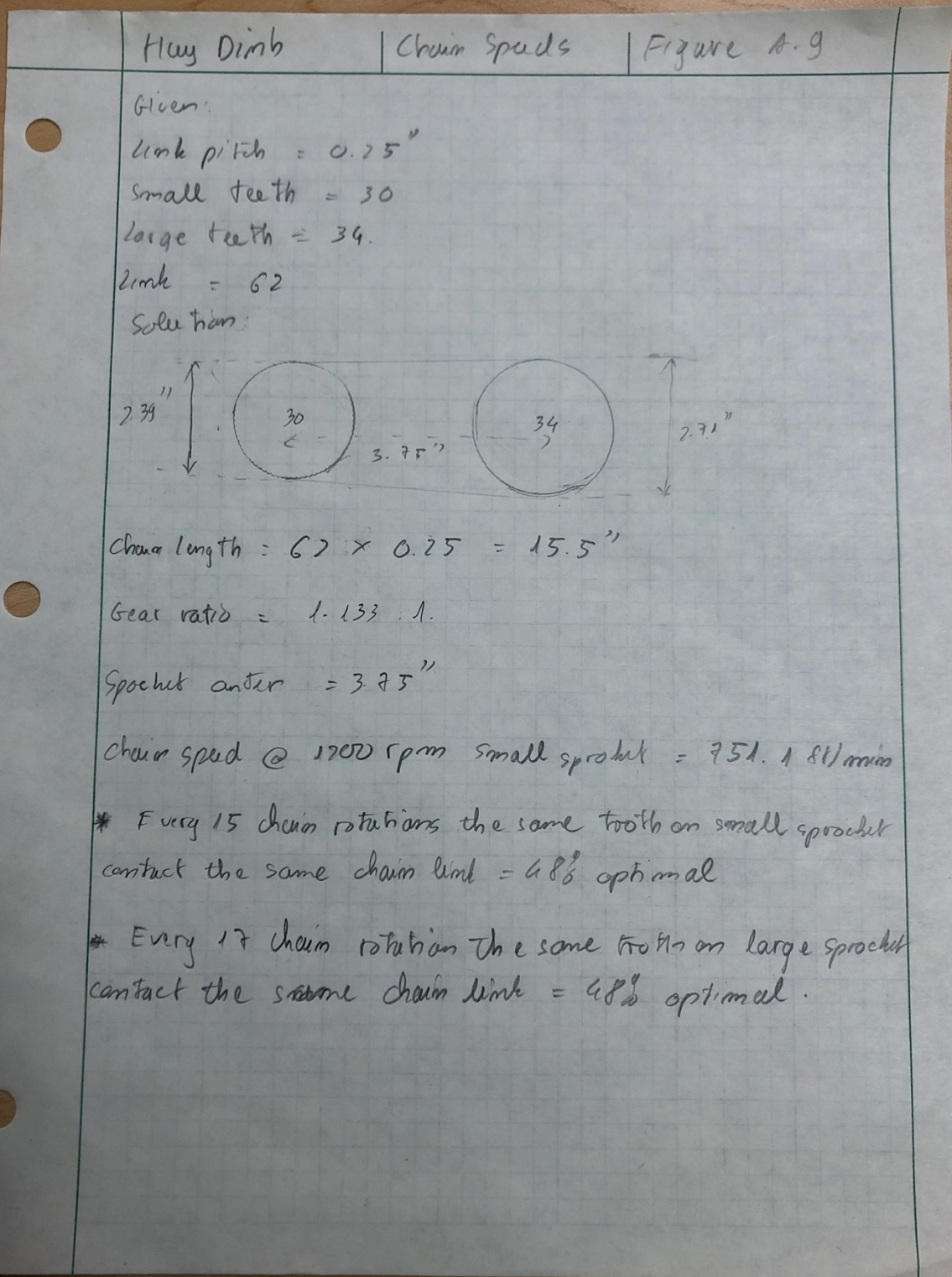


Figure A.10 Cooling Fan

Iluy Dimb	Cooling Fan	Figure A.10
<p>Given:</p> <p>Power = 12 V DC</p> <p>Current = 1.8 A</p> <p>Watt = 36 W</p> <p>Speed = 400 RPM</p> <p>Solution:</p> $\begin{aligned}\text{Torque} &= 9.5488 \times \text{Power (kW)} / \text{speed} \\ &= 9.5488 \times 36 \times 10^{-3} / 400 \\ &= 0.86 \text{ N.m}\end{aligned}$		

Figure A.11 Pitch Diameter

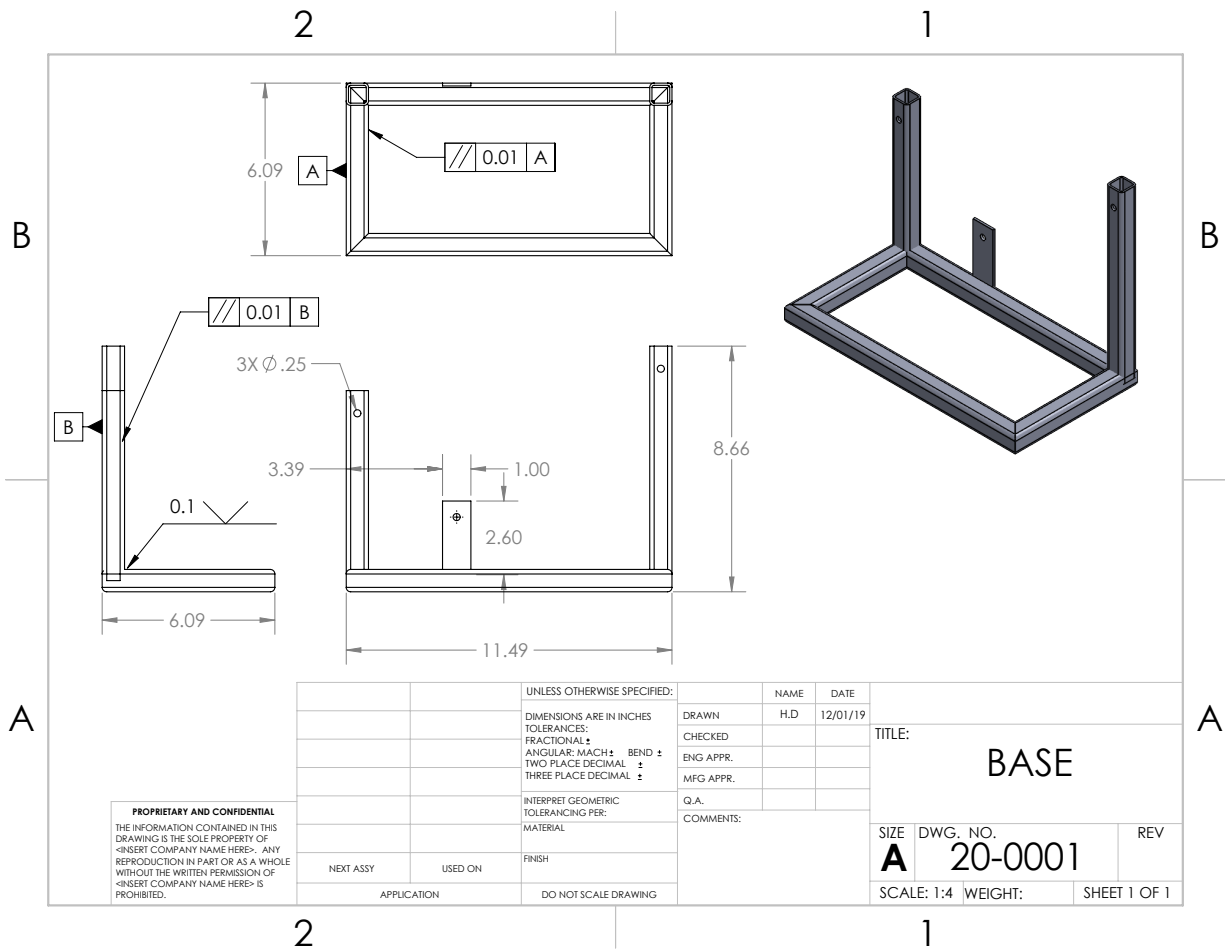
Given Data	Pitch Diameter	Figure A.11
<p>Given:</p> <p>pitch, $p = 1/4 \text{ in} = 0.25''$</p> <p>$N_1 = 30 \text{ teeth}$</p> <p>$N_2 = 34 \text{ teeth}$</p> <p>Find: Pitch Diameter of sprocket</p> <p>Solution:</p> $PD_1 = \frac{P}{\sin(180/N_1)} = \frac{0.25}{\sin(180/30)} = \boxed{2.39 \text{ in}}$ $PD_2 = \frac{P}{\sin(180/N_2)} = \frac{0.25}{\sin(180/34)} = \boxed{2.7 \text{ in}}$		

Figure A.12 Theoretical center distance

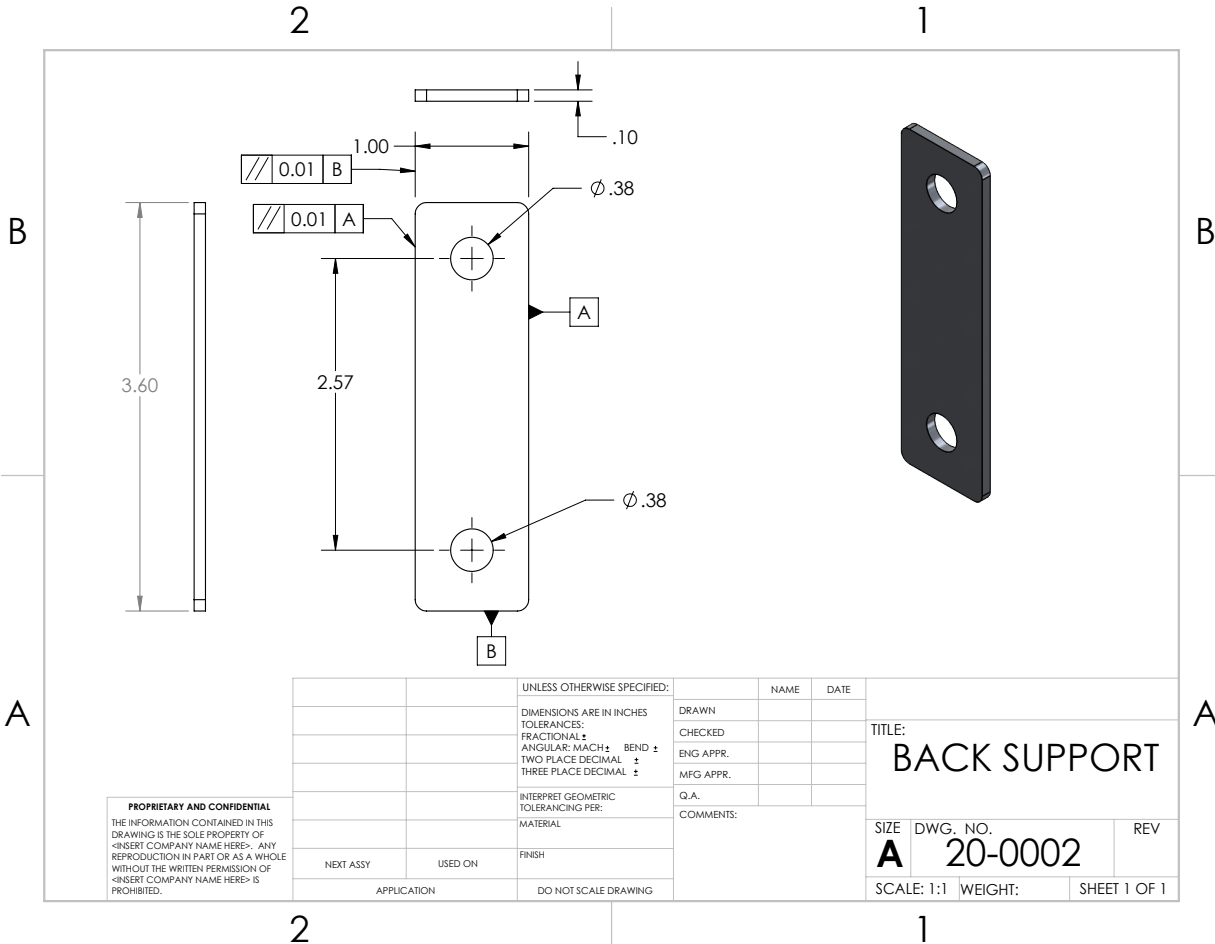
Hwy Drive	Theoretical center distance	Figure A.12
<p>Given: Chain length $L_c = 155'' = 394 \text{ mm}$.</p> <p>$N_1 = 30 \text{ teeth}$</p> <p>$N_2 = 34 \text{ teeth}$</p>	<p>Find: calculated, actual theoretical center distance</p> <p>Solution:</p>	
$CD = \frac{1}{4} \left(L_c - \frac{N_2 + N_1}{2} + \sqrt{\left(L_c - \frac{N_2 + N_1}{2} \right)^2 - \frac{8(N_2 - N_1)^2}{4\pi^2}} \right)$ $= \frac{1}{4} \left(394 - \frac{34 + 30}{2} + \sqrt{\left(394 - \frac{34 + 30}{2} \right)^2 - \frac{8(34 - 30)^2}{4\pi^2}} \right)$ $= \frac{1}{4} (394 - 32 + \sqrt{(394 - 32)^2 - 3.24})$	<p>$CD = 180 \text{ pitches.}$</p>	
<p>$\rightarrow CD = 180 \times 0.25 = \boxed{45.25 \text{ mm}}$</p>		

APPENDIX B – DRAWINGS

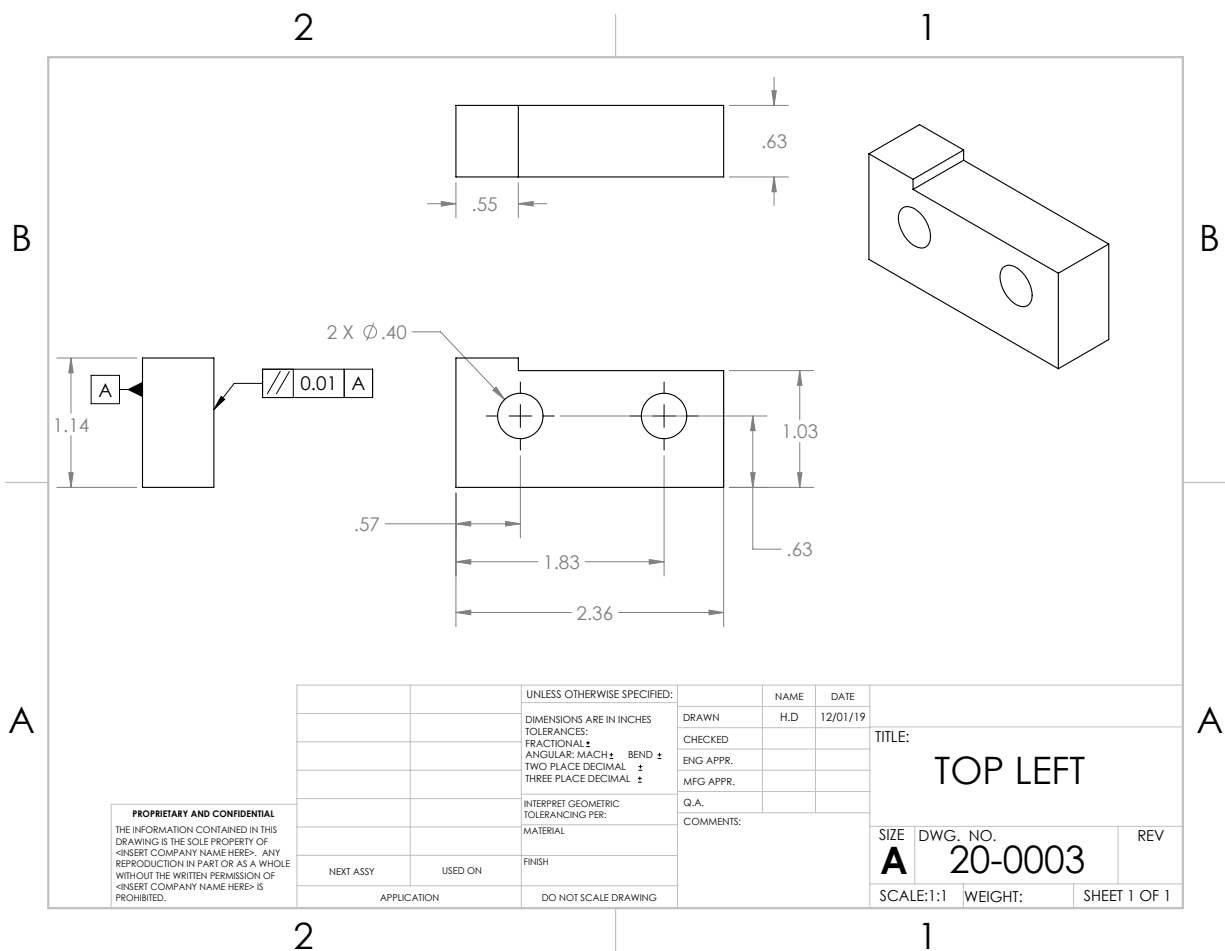
B1 – Base



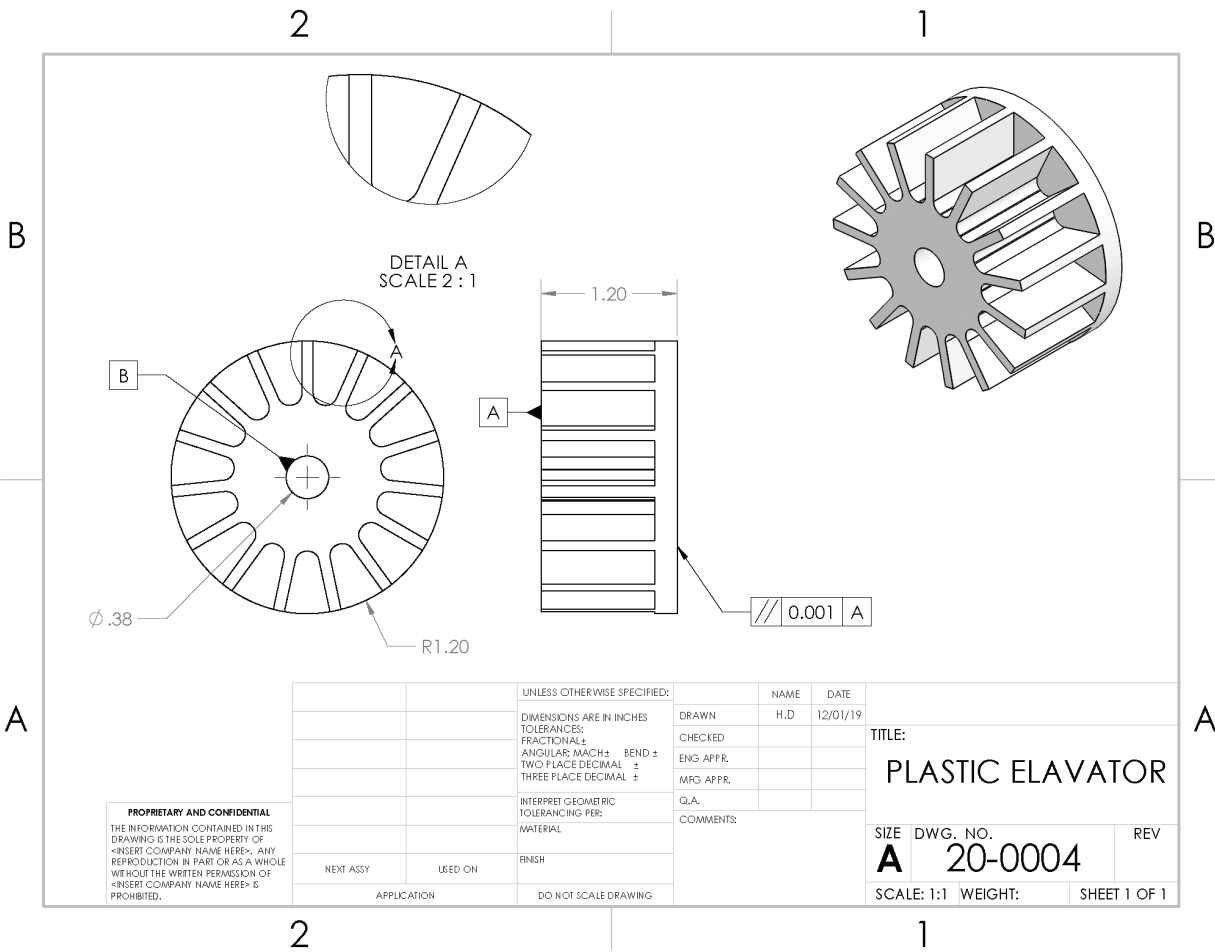
B2 – Back Support



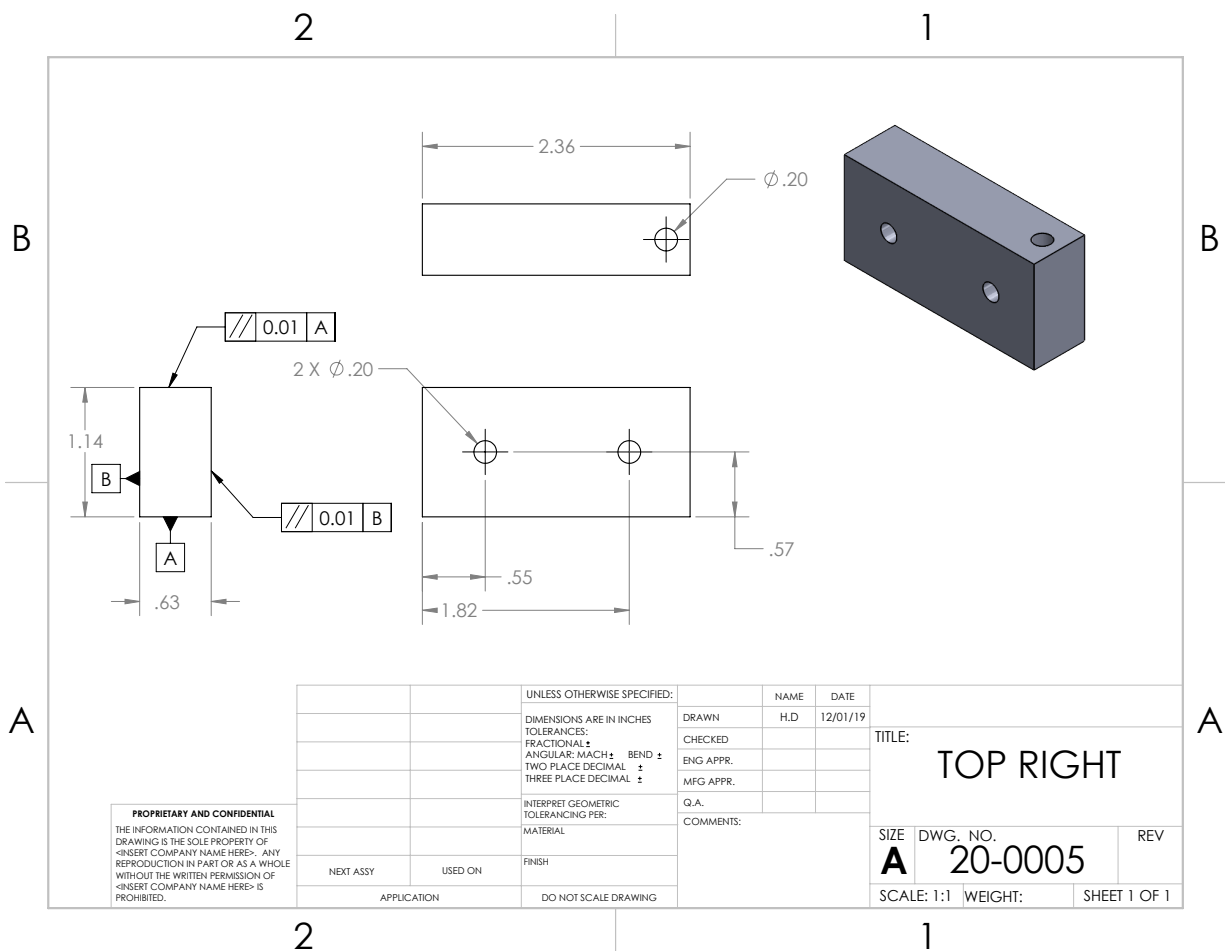
B3 – Top Left



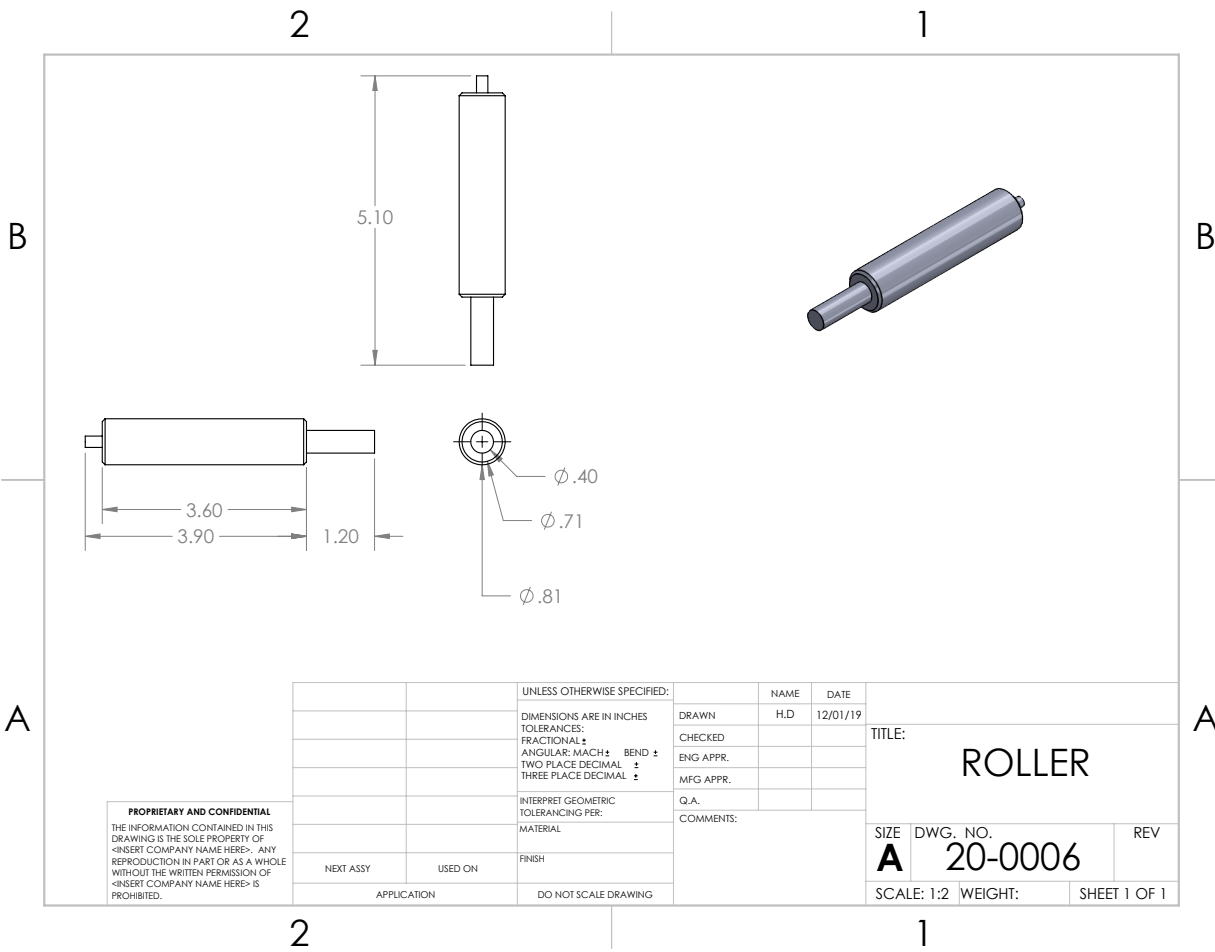
B4 – Plastic Elevator



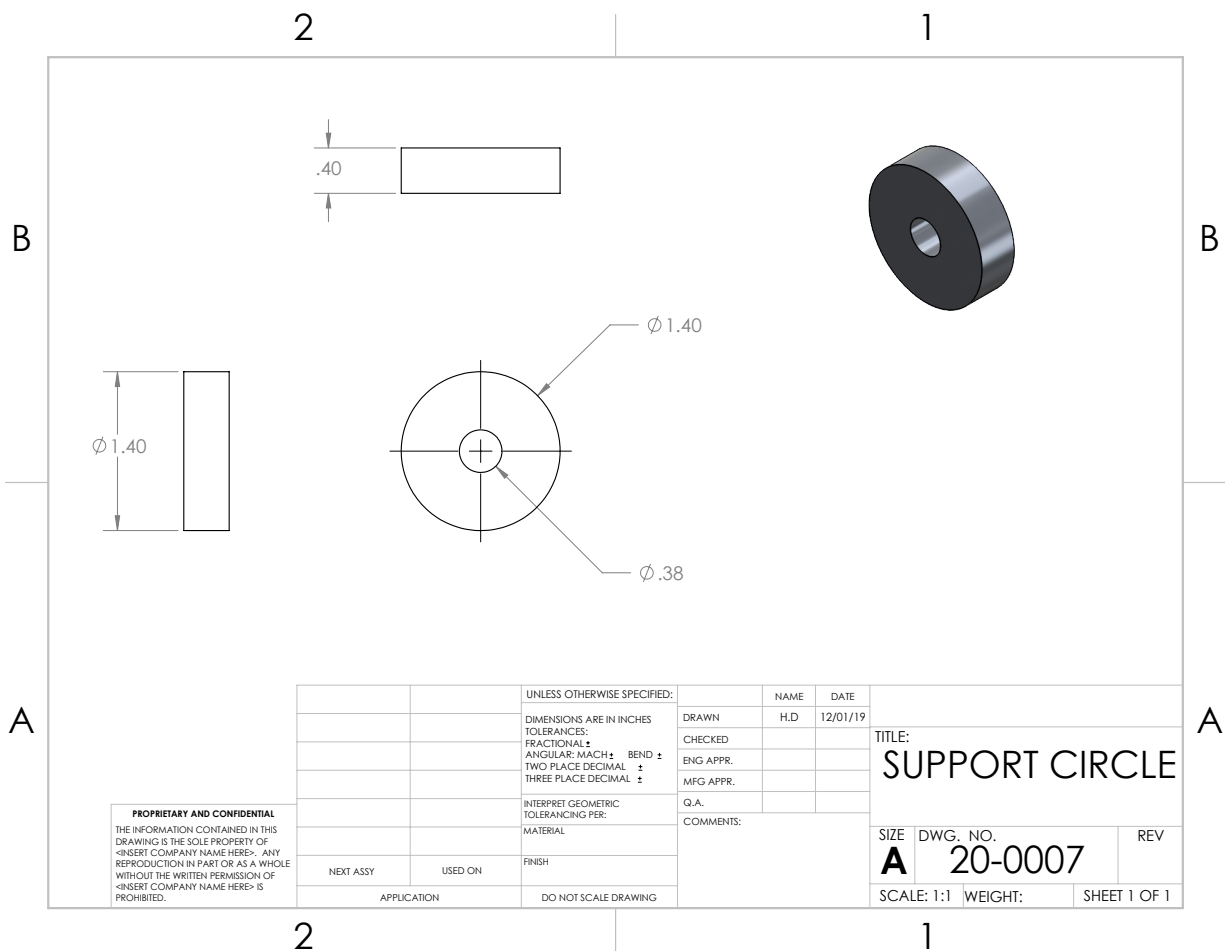
B5 – Top Right



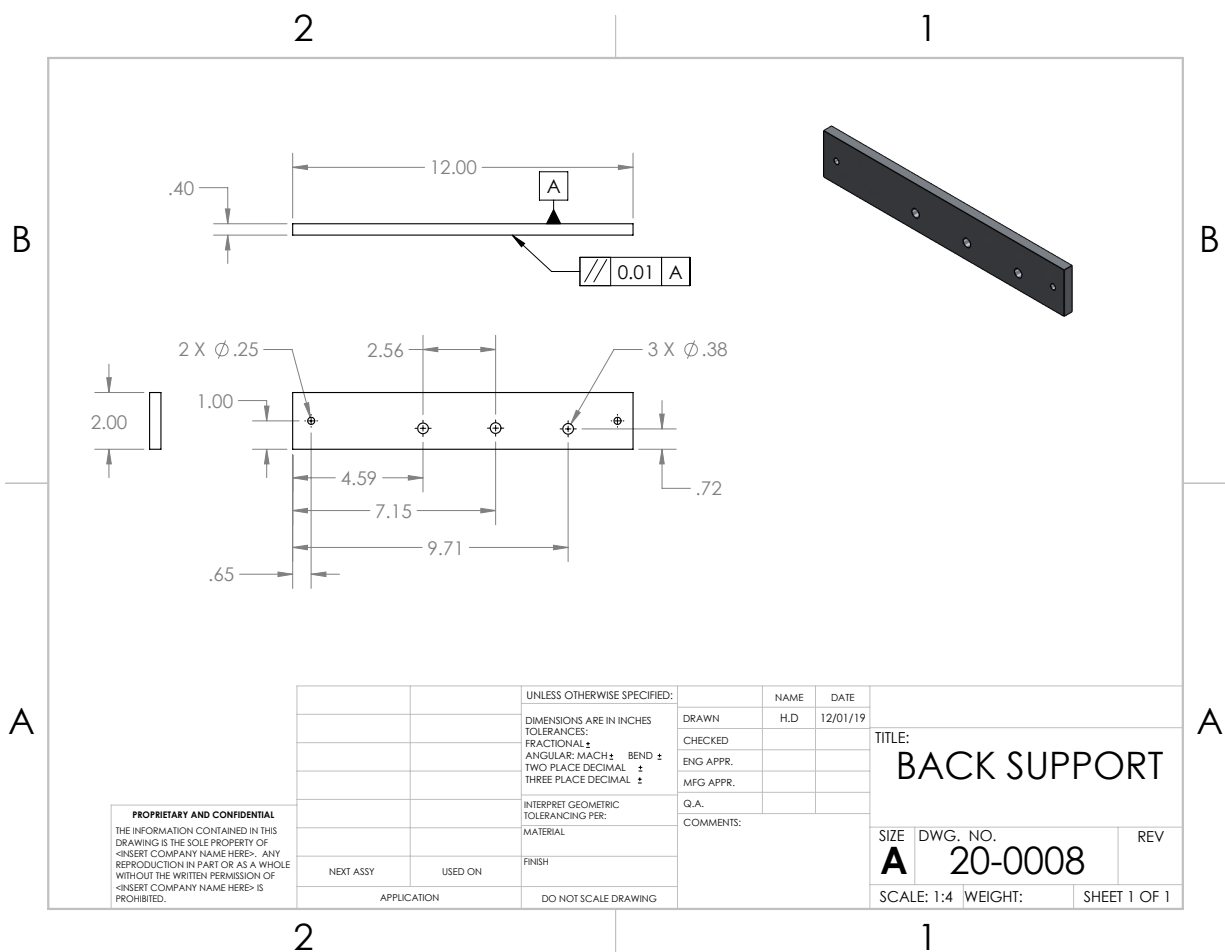
B6 – Roller



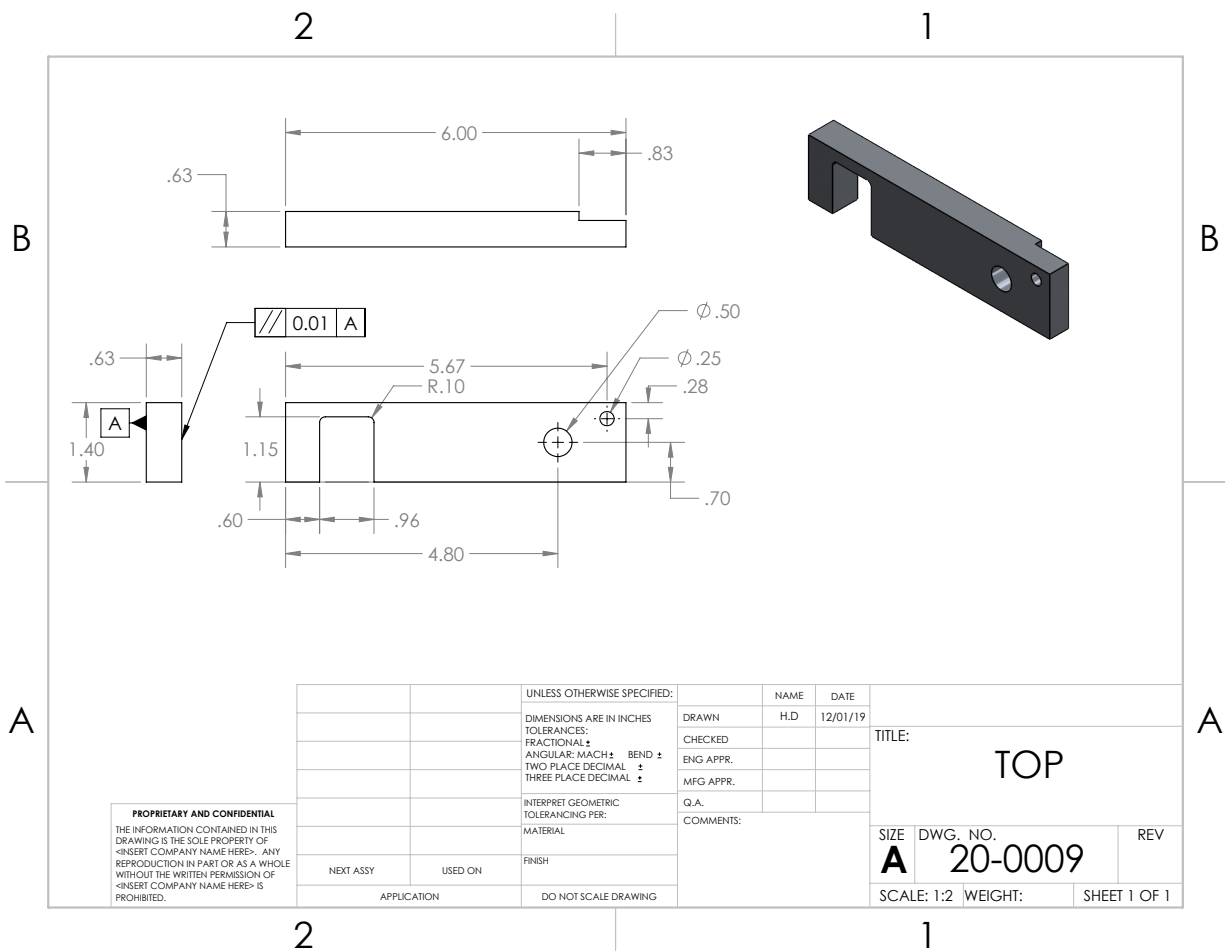
B7 – Support Circle



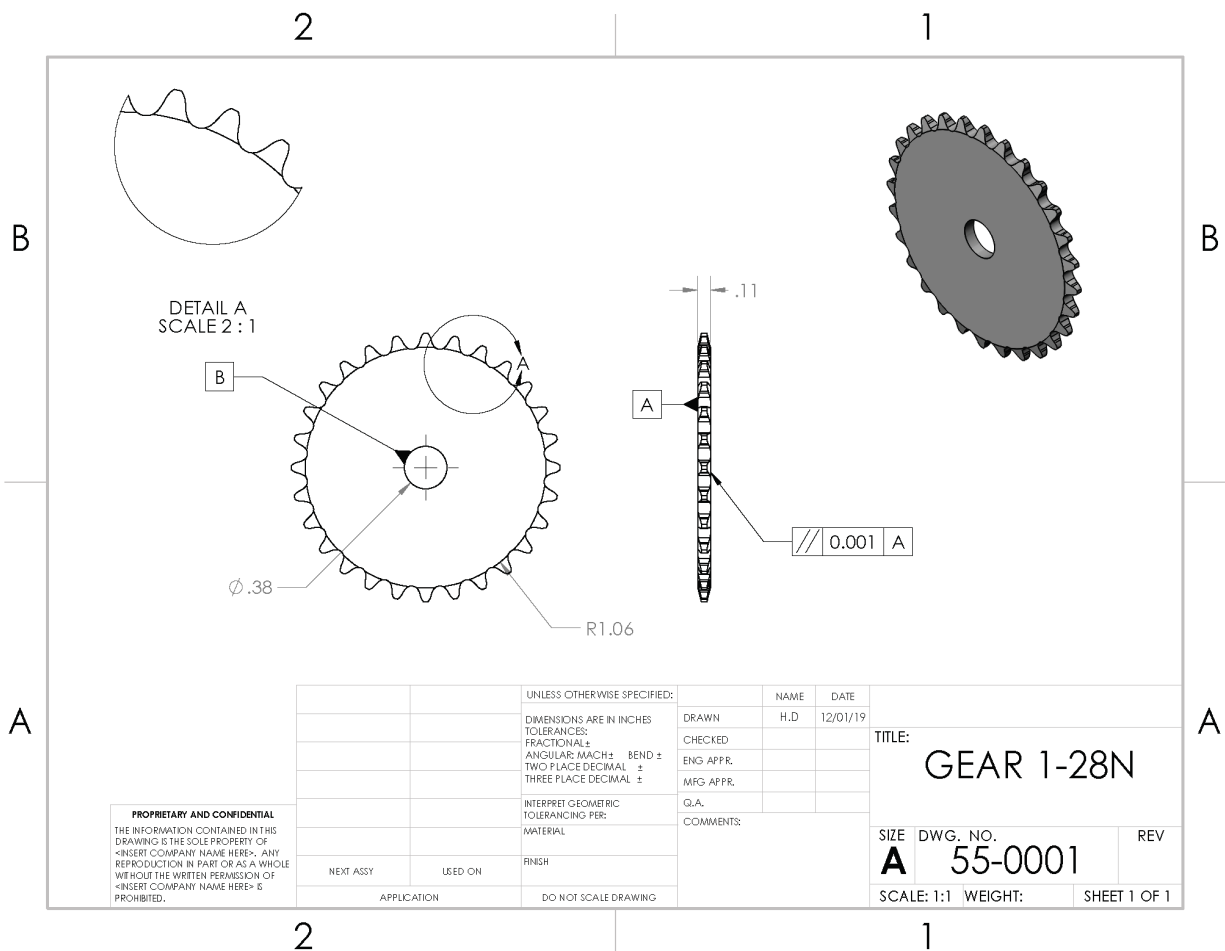
B8 – Back Support



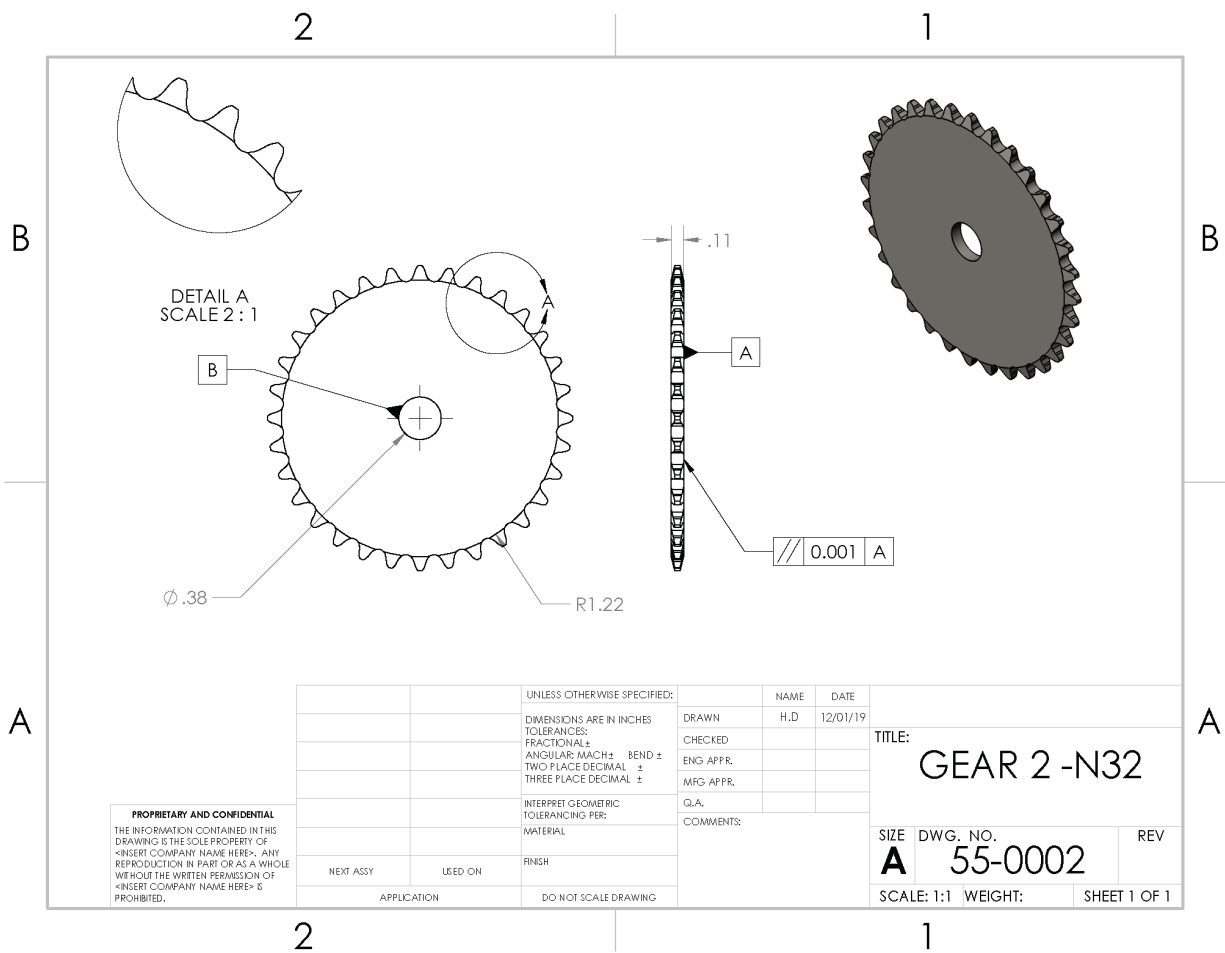
B9 – Top



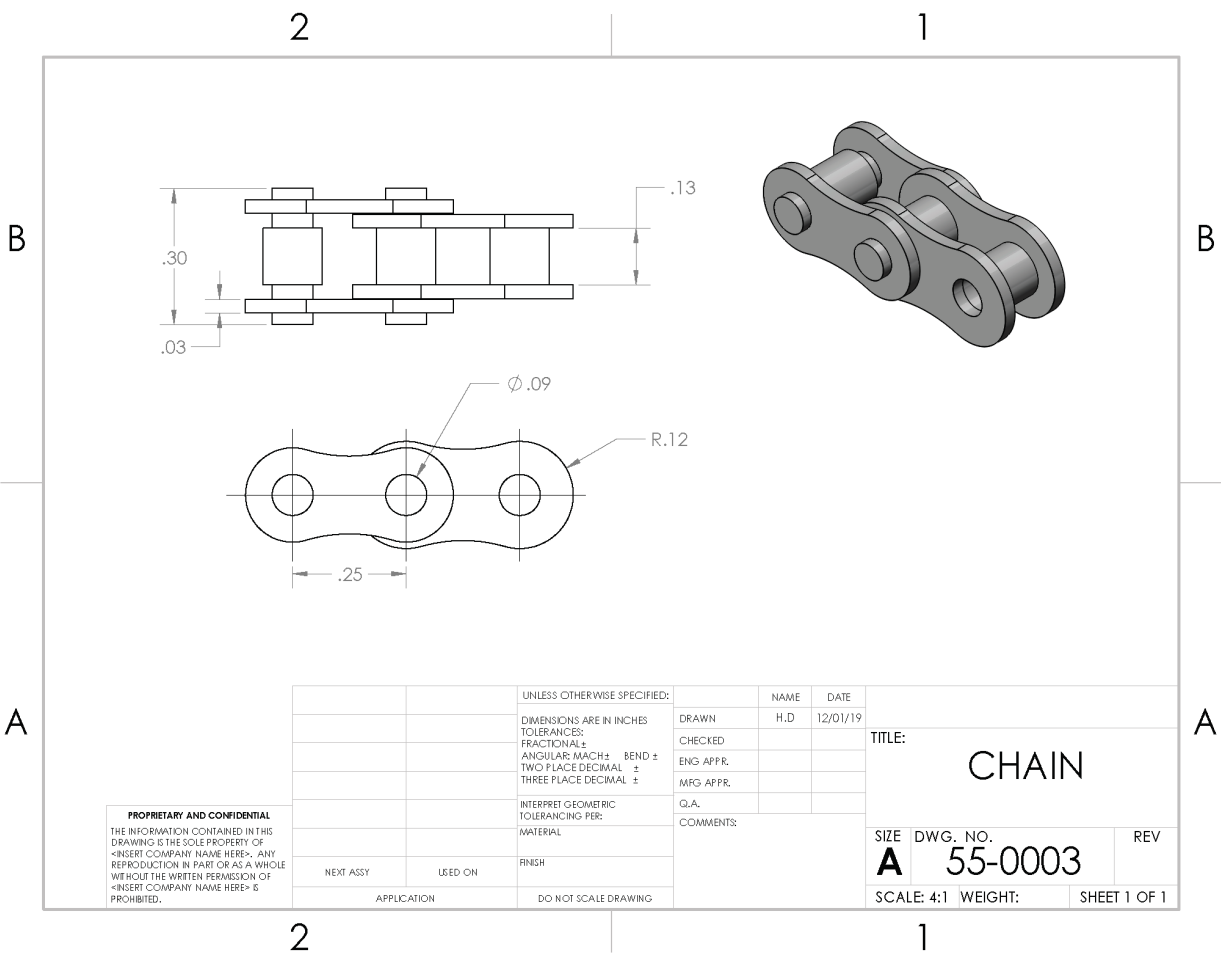
B10 – Gear 1 – N28



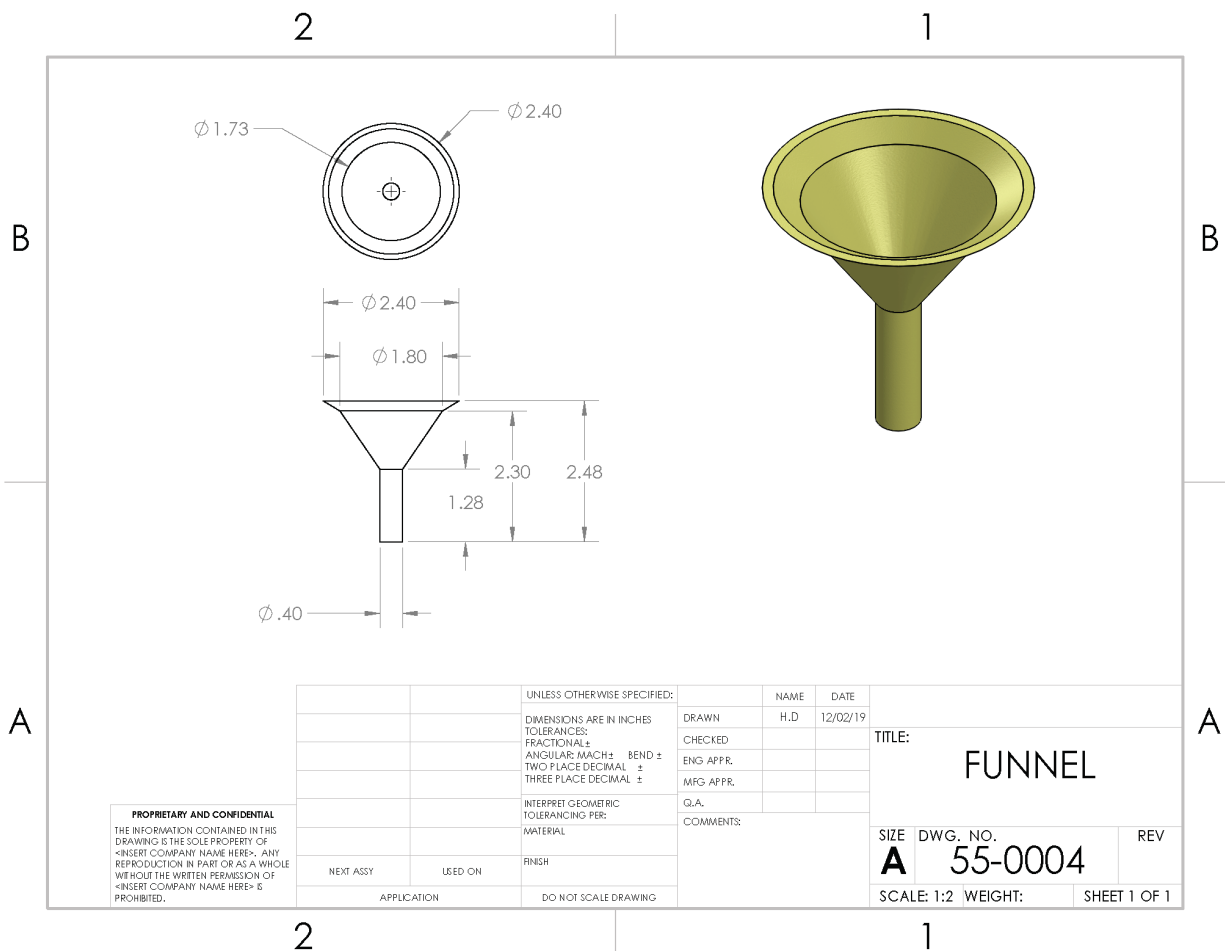
B11 – Gear 2 – N32



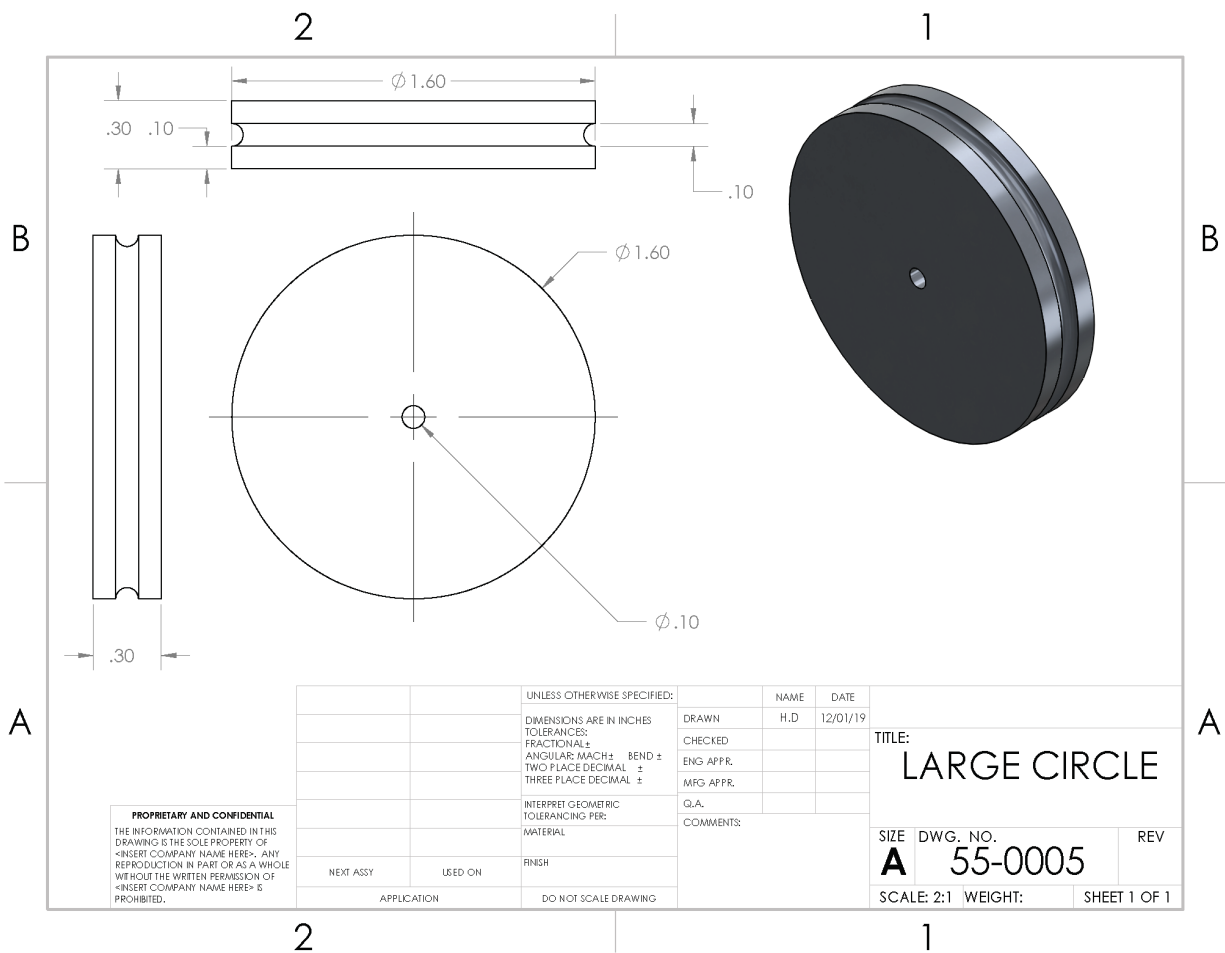
B12 – Chain



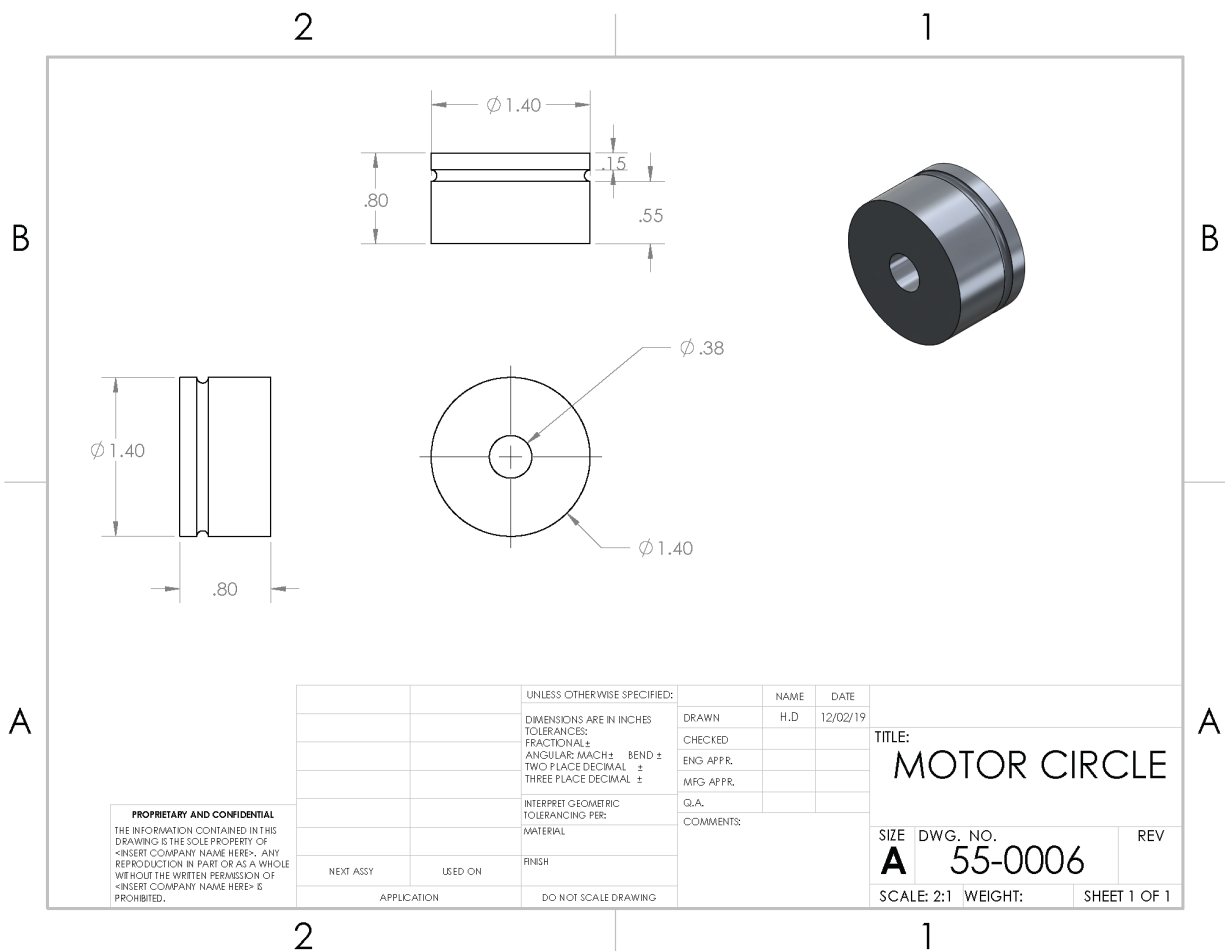
B13 – Funnel



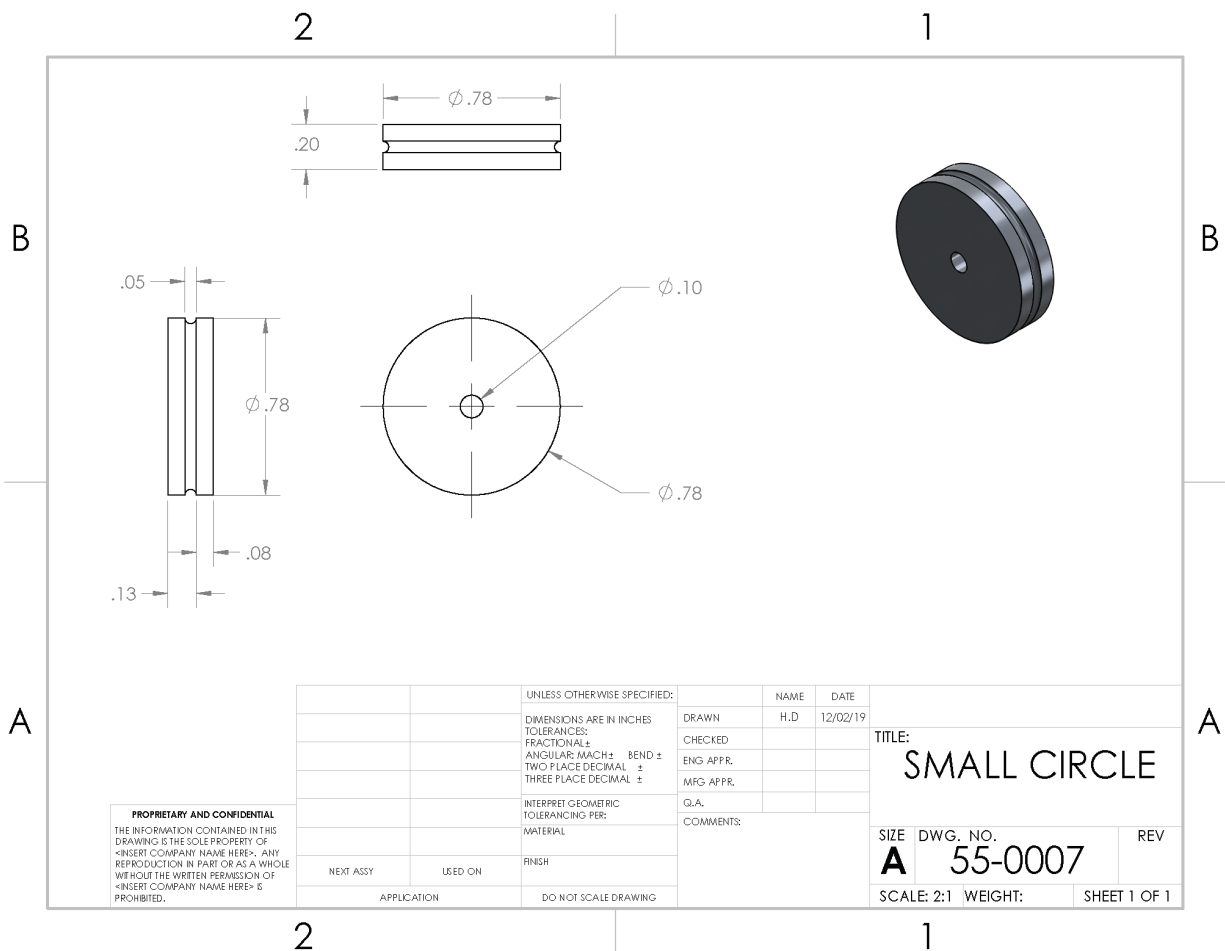
B14 – Large Circle



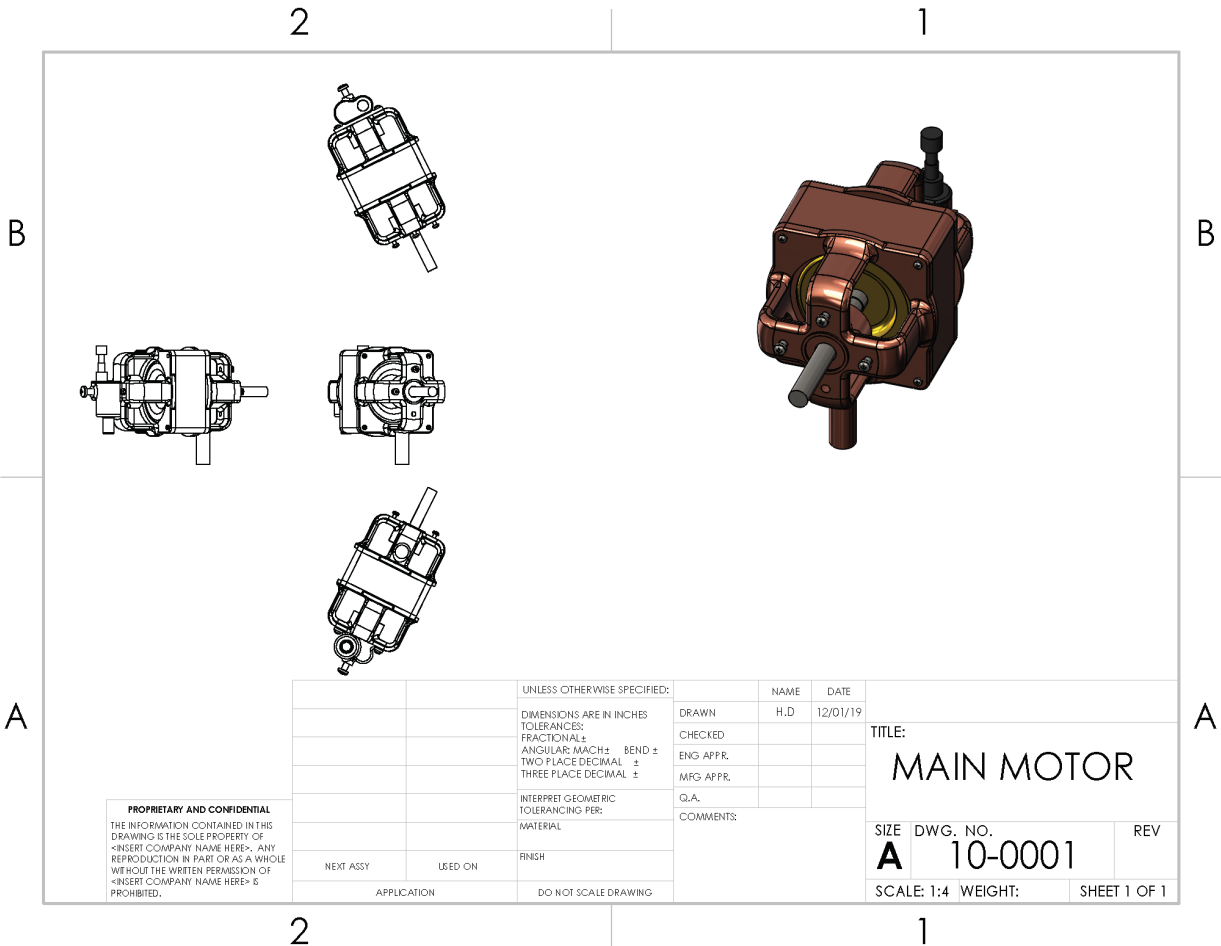
B15 – Motor Circle



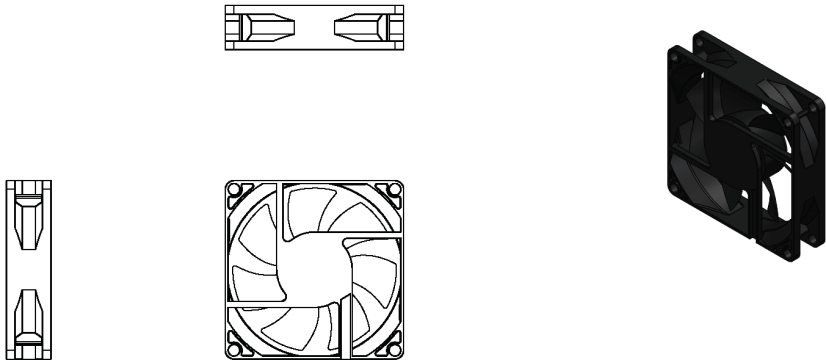
B16 – Small Circle



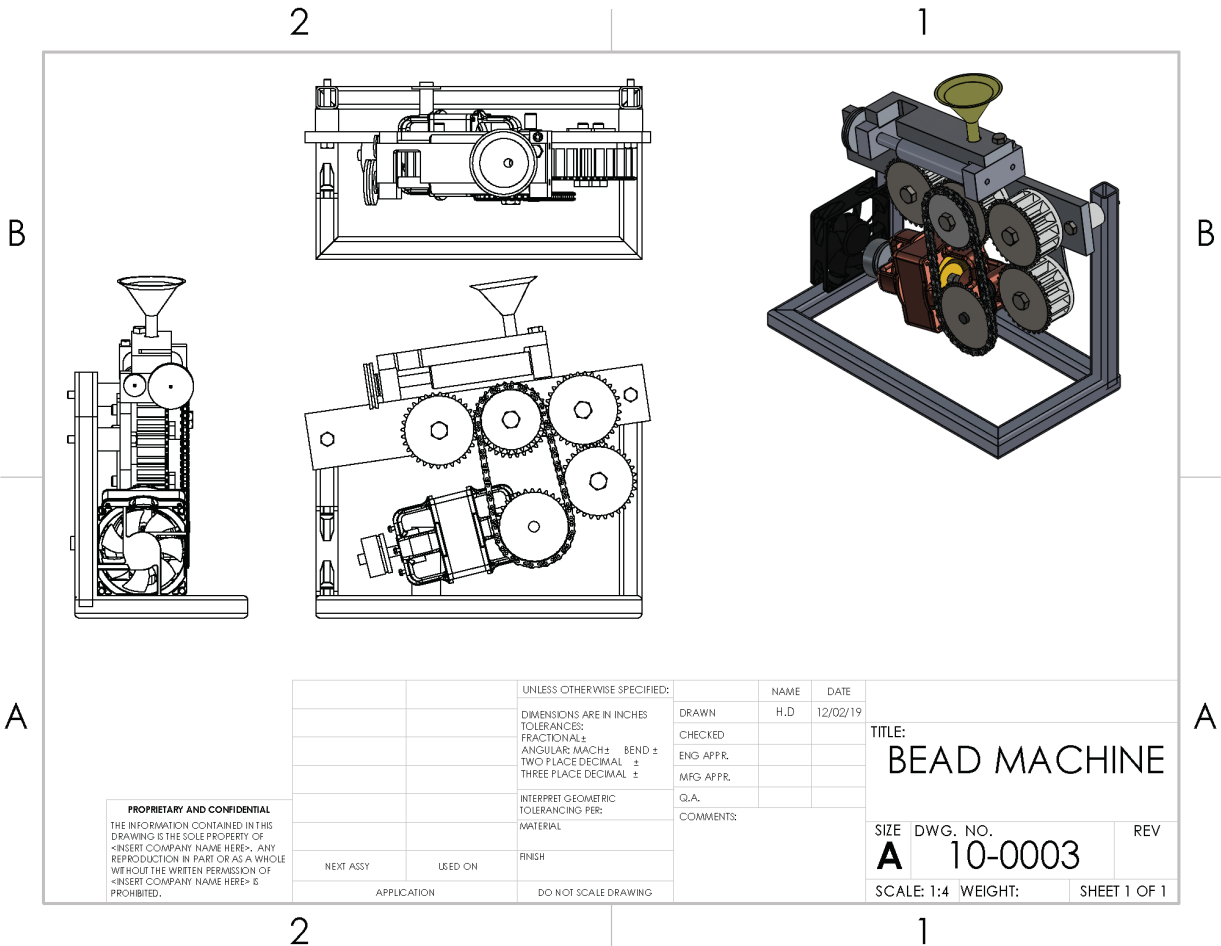
B17 – Main Motor Assembly



B18 – Cooling Fan

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B	<div></div>				B																																																														
A	<table border="1"><tr><td colspan="2" rowspan="5"><div>PROPRIETARY AND CONFIDENTIAL THE INFORMATION CONTAINED IN THIS DRAWING IS THE SOLE PROPERTY OF <INSERT COMPANY NAME HERE>. ANY REPRODUCTION IN PART OR AS A WHOLE WITHOUT THE WRITTEN PERMISSION OF <INSERT COMPANY NAME HERE> IS PROHIBITED.</div></td><td colspan="2">UNLESS OTHERWISE SPECIFIED:</td><td colspan="2">NAME</td><td colspan="2">DATE</td></tr><tr><td colspan="2">DIMENSIONS ARE IN INCHES</td><td colspan="2">DRAWN</td><td colspan="2" rowspan="4">TITLE: COOLING FAN</td></tr><tr><td colspan="2">TOLERANCES:</td><td colspan="2">CHECKED</td></tr><tr><td colspan="2">FRACTIONAL ±</td><td colspan="2">ENG APPR.</td></tr><tr><td colspan="2">ANGULAR: MACH ± BEND ±</td><td colspan="2">MFG APPR.</td></tr><tr><td colspan="2">TWO PLACE DECIMAL ±</td><td colspan="2">Q.A.</td><td colspan="2">COMMENTS</td><td>SIZE</td><td>DWG. NO.</td><td>REV</td></tr><tr><td colspan="2">THREE PLACE DECIMAL ±</td><td colspan="2">INTERPRET GEOMETRIC TOLERANCING PER:</td><td colspan="2"></td><td>A</td><td>10-0002</td><td></td></tr><tr><td colspan="2">NEXT ASSY</td><td colspan="2">USED ON</td><td colspan="2">MATERIAL</td><td colspan="3">SCALE: 1:2 WEIGHT: SHEET 1 OF 1</td></tr><tr><td colspan="2">APPLICATION</td><td colspan="2">DO NOT SCALE DRAWING</td><td colspan="2">FINISH</td><td colspan="3"></td></tr></table>				<div>PROPRIETARY AND CONFIDENTIAL THE INFORMATION CONTAINED IN THIS DRAWING IS THE SOLE PROPERTY OF <INSERT COMPANY NAME HERE>. ANY REPRODUCTION IN PART OR AS A WHOLE WITHOUT THE WRITTEN PERMISSION OF <INSERT COMPANY NAME HERE> IS PROHIBITED.</div>		UNLESS OTHERWISE SPECIFIED:		NAME		DATE		DIMENSIONS ARE IN INCHES		DRAWN		TITLE: COOLING FAN		TOLERANCES:		CHECKED		FRACTIONAL ±		ENG APPR.		ANGULAR: MACH ± BEND ±		MFG APPR.		TWO PLACE DECIMAL ±		Q.A.		COMMENTS		SIZE	DWG. NO.	REV	THREE PLACE DECIMAL ±		INTERPRET GEOMETRIC TOLERANCING PER:				A	10-0002		NEXT ASSY		USED ON		MATERIAL		SCALE: 1:2 WEIGHT: SHEET 1 OF 1			APPLICATION		DO NOT SCALE DRAWING		FINISH					A
<div>PROPRIETARY AND CONFIDENTIAL THE INFORMATION CONTAINED IN THIS DRAWING IS THE SOLE PROPERTY OF <INSERT COMPANY NAME HERE>. ANY REPRODUCTION IN PART OR AS A WHOLE WITHOUT THE WRITTEN PERMISSION OF <INSERT COMPANY NAME HERE> IS PROHIBITED.</div>		UNLESS OTHERWISE SPECIFIED:		NAME			DATE																																																												
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		ANGULAR: MACH ± BEND ±		MFG APPR.																																																															
TWO PLACE DECIMAL ±		Q.A.		COMMENTS		SIZE	DWG. NO.	REV																																																											
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B19 – Bead Machine Assembly



APPENDIX C + D

Part and budget list

PARTS LIST AND BUDGET							
SENIOR PROJECT TITLE		Bead String Machine					
					Cost:		
ITEM ID	ITEM Description	Item Source	Price/Cost (US Dollars) (\$ / hour)	Quantity (or hrs)	Subtotal	Actual \$	
1	Main Motor	Ebay	40	1	40		
2	Silicone Rubber Roller	Ebay	21	2	42		
3	Funnel	Ebay	10	1	10		
4	Rubber band	Home Depot	10	1	10		
5	Spur gear 1	Mcmaster	22.85	1	22.85		
6	Spur gear 2	MCmaster	25	1	25		
7	Spur gear 3	MCmaster	25	4	100		
8	Cooling Fan (Square 12mm x12mm)	Ebay	15	1	15		
9	Plastic elevator circle	Ebay	5	5	25		
10	Nuts, Bolts and Washers	Home Depot	40	0.5	20		
11	Square Tube 6063-T52- Extruded (84")	onlinemetals.com	7.35	2	14.7		
12	Spray paint	Home Depot	5	2	10		
				Tot Est.\$	334.55	0	Tot Act. \$

APPENDIX E

Note:
Note:
Note: June y-z Spr Finals

PROJECT TITLE: _Auto Bead String Machine_

Principal Investigator.:__Huy Dinh__

Task Description ID	Duration (hrs)	Est.	Actual	%Comp.	S	O	N	D	J	F	M	A	M	J
					October	November	Dec	January	February	March	April	May	June	
1 Proposal*														
1a Outline	1	1												
1b Intro	2	2												
1c Methods	2	2												
1d Analysis	18	17												
1e Discussion	6	6												
1f Parts and Budget	4	4												
1g Drawings	40	40												
1h Schedule	8	8												
1i Summary & Appx	8	8												
subtotal:	89	88												
2 Analyses														
2a Roller Frame Design	1	1												
2b Funnel Support	1	1												
2c Roller Cover	0.5	0.5												
2d Induction Motor	0.5	0.5												
2e Main motor	1	1												
2f Spur Gear 1	1	1												
2g Spur Gear 2	1	1												
2h Spur Gear 3	1	1												
2i Chain Speed	1.5	1.5												
2j Colling Fan	0.5	0.5												
2k Pitch Diameter	1	1												
2l Theoretical Center Distance	1	1												
subtotal:	11	11												
3 Documentation														
3a Part 1 Base	2	2												
3b Part 2 Back Support	0.5	0.5												
3c Part 3 Top Left	1	1												
3d Part 4 Plastic Elevator	1	1												
3e Part 5 Top Right	1	1												
3f Part 6 Roller	1	1												
3g Part 7 Support Circle	1	1												
3h Part 8 Back Support	1	1												
3i Part 9 Top	1	1												
3j Part 10 Gear 1 - N28	1	1												
3k Part 12 Chain	1.5	2												
3m Part 13 Funnel	0.5	0.5												
3n Part 14 Large Circle	0.5	0.5												
3o Part 15 Motor Circle	0.5	0.5												
3p Part 16 Small Circle	0.5	0.5												
3r Part 17 Main Motor Assembly	3	3												
3s Part 18 Colling Fan	1	1												
3t Final Assembly	22	23												
4 Proposal Mods														
4a Project Schedule	3	3												
4b Project Part	2	2												
subtotal:	5	5												
5 Part Construction														
5a Buy Part 11	0.5	0.5												
5b Buy Part 11	0.5	0.5												
5c Buy Part 12	0.5	0.5												
5d Buy Part 13	0.5	0.5												
5e Buy Part 14	0.5	0.5												
5f Buy Part 15	0.5	0.5												
5g Buy Part 16	0.5	0.5												
5h Buy Part 17	0.5	0.5												
5i Manufacture Part 1	3	3												
5j Manufacture Part 2	1	1												
5k Manufacture Part 3	1.5	1												
5l Manufacture Part 4 (x5)	1	1												
5m Manufacture Part 5	1.5	1.5												
5n Manufacture Part 6 (x2)	4	6												
5o Manufacture Part 7	0.5	0.5												
5p Manufacture Part 8	1	1												
5r Manufacture Part 9	1	1												
5t Manufacture Part 10	18.5	20												
6 Device Construct														
6a Assemble Gear System	4	5												
6b Assemble Base System	3	3												
6c Assemble Roller System	5	5												
6d Assemble Machine	4	4												
6d Take Dev Pictures	0.5	1												
6e Update Website	2	2												
subtotal:	18.5	20												
10 Device Evaluation														
10a List Parameters	1	1												
10b Design Test&Scope	3	2.5												
10c Obtain resources	1	1												
10d Make test sheets	1	1												
10e Plan analyses	1	1												
10f Instrument Robot	2	2												
10g Test Plan*	1	1												
10h Perform Evaluation	2	2												
10i Take Testing Pics	1	1												
10h Update Website	1	1												
subtotal:	12	11.5												
11 495 Deliverables														
11a Get Report Guide	1	1												
11b Make Rep Outline	1	1												
11c Write Report	3	3												
11d Make Slide Outline	1	1												
11e Create Presentation	1	1												
11f Make CD Deliv. List	1	1												
11g Write 495 CD parts	1	1												
11h Update Website	1	1												
11i Project CD*	10	10												
Total Est. Hours= 186 188.5 =Total Actual Hrs														
Labor	100	18600												
Note: Deliverables*														
Draft Proposal														
Analyses Not														
Document Mods														
Final Proposal														
Part Construction														
Device Construct														
Device Evaluation														
495 Deliverables														

APPENDIX G
Testing Report

Task	Requirement	Actual	Success
1. Weight	No more than 20lbs	15lbs	Yes
2. Cost	Less than \$400	\$350	Yes
3. Production	150 beads per minute	372 beads per minute	Yes








APPENDIX J

Engineering Technologies, Safety, and Construction Department

JOB HAZARD ANALYSIS Auto Bead Stringing Machine

Prepared by: Huy Dinh	Reviewed by:
	Approved by:

Location of Task:	Central Washington University
Required Equipment / Training for Task:	The required equipment of Auto bead string machine are gloves, eye protection, welding mask, Appropriate footwear, hearing protection and protective clothing
Reference Materials as appropriate:	Drilling, welding, painting

Personal Protective Equipment (PPE) Required (Check the box for required PPE and list any additional/specific PPE to be used in "Controls" section)						
						
Gloves	Dust Mask	Eye Protection	Welding Mask	Appropriate Footwear	Hearing Protection	Protective Clothing
X		X	X	X	X	X
Use of any respiratory protective device beyond a filtering facepiece respirator (dust mask) is voluntary by the user.						

PICTURES (if applicable)	TASK DESCRIPTION	HAZARDS	CONTROLS
	Device Operation: Drill Feed the drill with the feed	Injury caused by breaking the bit	Feed with the appropriate pressure. Use the appropriate bit for the type of metal. Wear eye protection
		Eye or skin damage from cutting oil	Use the lowest RPM. Wear eye protection. Wear a long sleeved shirt.
	Device Operation: Grinding Turn on the machine and allow the grinding wheel to rotate to speed. Firmly hold the piece to be grounded up to the grinding wheel. Grind the piece. Turn off the machine and wait for the wheel to stop rotating.	Lacerations and severe eye damage from flying glass and ground bits Inhalation of fine dust particles. Burns caused by heat from friction and machine operation	Wear appropriate gloves and safety glasses. Wear a dust mask.
	Device Operation: Saw Vertical Align material on saw platform.	Muscle strain	Position body to maintain balance. Maximize use of legs. Avoid twisting and overextending.
	Device Operation: Welding Set-up material and equipment.	Inhalation. Burn, fire.	Ensure PPE is worn. Work in welding hood.

Engineering Technologies, Safety, and Construction Department

	Device Operation: Welding Clamp / fix in place, weld as required	Struck against / by. Burns. Welder's flash.	Ensure PPE is worn. Wear cotton long sleeved shirt and appropriate PPE.
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APPENDIX H

Resume

HUY DINH

Address: 1307 17th St NE, Auburn, WA-98002, USA

Cell Phone: 510-925-8867 - **E-Mail:** anhuydinh90@gmail.com

CAREER SUMMARY

- Working on Bachelor degree of Sciences majoring in Mechanical Engineering Technology expected graduate in 2020
- 4 years' experience in managing events with budget over \$200,000 per event. Provide excellent service for international corporation such as: Coca-Cola, Korean Air, Nike, NCH Corporation, Abbott, McKinsey, Colliers.
- Experience of developing and managing human capital, budget, and business partner relationships

EDUCATION

Central Washington University (August 2017-Present)

- Major in Mechanical Engineering Technology, current GPA 3.5
- ASME member

Towson University, Maryland (August 2010 – May 2013)

- Bachelor of Sciences, Business Administration major, graduated May 2013
- Vice President of Vietnamese Student Association Group

WORKING EXPERIENCE

Event Planning Manager – Team Travel and Event Joint Stock Company (December 2015 –June 2017) – Viet Nam

- Responsible for all aspects of event management
- Managed budgets of up to \$200,000, for up to 350 attendees.

Successful Events:

- NCH Corporation event up to 400 participants with budget \$180,000
- McKinsey event up to 150 participants

Event Planning Executive – Oriental Destination (September 2014 – November 2015) – Viet Nam

- Managed budgets of up to \$100,000, for up to 150 attendees.

Successful Events:

- Local Partner for Ironman 70.3, Nike - Corporate Social Responsibility, Abbott and Collier International, World Spa Awards, Color me run and Danang International Marathon 2015

Shuttle Bus Service Manager (service for 5 stars resorts) – Oriental Destination (December 2014- November 2015)

- Over 1300 customers use service each month with revenue over \$6000 for each month.
- Clients: Novotel, Hyatt, Grand Mercure, Holiday Beach, Premier Village, Vinpearl Premium.

Event Planning Coordinator – Hyatt Regency Resort and Spa Danang (April 2014 – July 2014) – Viet Nam

- Responsible for every logistical element of event, food and beverages, room set-ups, audiovisuals, entertainment.

Successful Events: Viet Nam Petrolimex, SHIER, APOT, Korean Airline

SKILLS

- Courses work: Lean Manufacturing, Mechanical Design, CNC programming, Advance Machine, Computer Aided design Manufacturing, Casting
- Proficient in CNC machine, CNC programming, 3D-Solid Work, Auto-cad, Rhinoceros
- Strong attention to detail and accuracy, leadership skills, communication, negotiation and time management